

University of Edinburgh.

THESES PRIZE COMPETITION.

Thesis by

John Fraser

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The Study of 1000 Cases of Oblique Inguinal
Hernia occurring in Children - as an introduction to
some Observations upon the Descent of the Testis.

THESIS for the Degree of Ch.M., 1910.

by

JOHN FRASER, M.B., Ch.B.



1.

INTRODUCTION.

This article was originally intended to investigate and reproduce the results obtained from the study of 1000 cases of Inguinal Hernia, the condition being limited to children 12 years of age and under.

But, like the Genii of the Arabian Nights, the subject has grown in the making. The ambiguity of the Processus Vaginalis has an attraction all its own, and eventually the subject of Inguinal Hernia resolved itself into an excuse, and introduction, for the study of that intensely interesting problem - "the descent of the testis."

The Clinical aspect of the question has not been neglected, and from the cases at our disposal, we have deduced many interesting features. Some are already well known, others we think we can claim as original.

But the study of a series of cases must essentially be a limited one. It affords but a small outlet for originality, and its results are obtained through the prosaic road of calculation, percentage, and statistic.

In addition therefore, we have dealt with the question of testicular descent in the Human Being, and the investigations have been carried out upon a series of/
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of embryos and Foeti.

We have classified the articles under the following headings:-

- A. The Method of testicular descent in the Human Foetus.
- B. The Anatomy of Inguinal Hernia.
- C. Some clinical features gained from a study of 1000 cases of oblique Inguinal Hernia as occurring in children under the age of 12 years.

THE PHYSIOLOGICAL DESCENT OF THE TESTIS IN THE
HUMAN FOETUS.

THE PHYSIOLOGICAL DESCENT OF THE TESTIS IN THE HUMAN FOETUS.

INTRODUCTION.

Apart from the physiological interest of the Process, the development and descent of the testis are important, in so far as they have a particular bearing upon the question of the Congenital origin of ^{the} Hernia sac.

As a Physiological occurrence it has aroused great interest, and the investigation of the phenomena has stimulated much original research.

We shall introduce our subject by giving a review of what is at present supposed to be the method of the descent: secondly, we shall note our own observations, and finally, we shall compare and criticise the combined results.

MORPHOLOGY.

The testis as the male primary generative organ exists as a specialized organ in all the vertebrata, and in some of the higher invertebrata. The higher the/
the/

the scale of development, the more complex does its structure become, and in the highest vertebrata, it normally leaves the abdomen and enters the scrotal pouch, there to remain.

The position of the testis in the mammalia gives us an idea of the stage of development of the species or subclass with which we are dealing.

This progressive development is seen not only in the position of the testis, but also in the presence and character of the Gubernaculum, and Processus Vaginalis.

The Monotremata show the lowest type, the testes are abdominal, no scrotum, no inguinal fold, no cremaster; while in the Echidna the Ligamentum Testis is joined to the vas deferens. In the Rodentia a scrotal pouch has developed into which the testes at certain times enter, to return within the abdomen during the Rutting period; the precursor of the cremaster muscle is seen in the Conus Inguinalis derived from the Transversalis and Internal Oblique muscles.

In the Perissodactyla a further stage is reached; the processus vaginalis is present; it remains widely open; the cremaster is well marked and is derived from the Internal Oblique.

The following taken from Berry Hart's "Physiological Descent of the testes:" 1908, shows well the progressive/

progressive development:-

"Monotremata. - Testes abdominal; no scrotum; no inguinal fold; no cremaster. Echidna shows ligamentum testis joined to vas deferens.

Marsupialia. - Suprapubic scrotum with processus vaginalis closed; mesorchium broad and four-angled; inguinal fold well developed.

Edentata. - Testes abdominal; position of testes really varies; may be primary abdominal, subintegumental, or secondary abdominal; no scrotum; no inguinal fold; cremaster has transverse and internal oblique fibres; no conus; in Dasypus sexcinctus, inguinal fold marked and runs to equivalent of processus vaginalis, ending in its fundus; in Dasypus novemcinctus, short conical cremaster sac from internal and transverse below aponeurosis of external oblique.

Cetacea. - Testes primary abdominal and no inguinal fold.

Proboscidea. - Testes abdominal.

Rodentia. - Testes in scrotal pouch, but return to abdomen at "rutting"; cremaster from transverse and internal oblique, and forms "conus inguinalis."

Insectivora. - Much as in rodentia; have conus inguinalis, but not always; testes in some; abdominal, and/

and no descent; in others, abdominal, and return to scrotum after rutting.

Chiroptera. - Testes return; conus present; cremaster from transverse and internal oblique.

Pinnipedia. - Testes extra-abdominal, subintegumental in inguinal canal; shallow cremaster sac from transverse and internal oblique; no scrotum; no return of testes in Phoca Vitulina.

Carnivora. - Show beginning involution of processus; cremaster from transversus.

Artiodactyla. - Processus vaginalis narrow; cremaster from internal oblique.

Perissodactyla. - More primitive conditions; processus vaginalis wide open; traces of inguinal ligament even in adults; cremaster from internal oblique and well marked.

Prosimia - (Lemurs) Processus vaginalis narrow; cremaster from internal oblique and transversus (mainly).

Primates. - Conditions very varied (v. Frankl, pp. 186 - 187), from simple to complex."

John Hunter, in 1786, was the first to scientifically reason out the descent of the testis as it occurs in the Human Foetus.

In "Observations on certain points of the Animal Economy" /

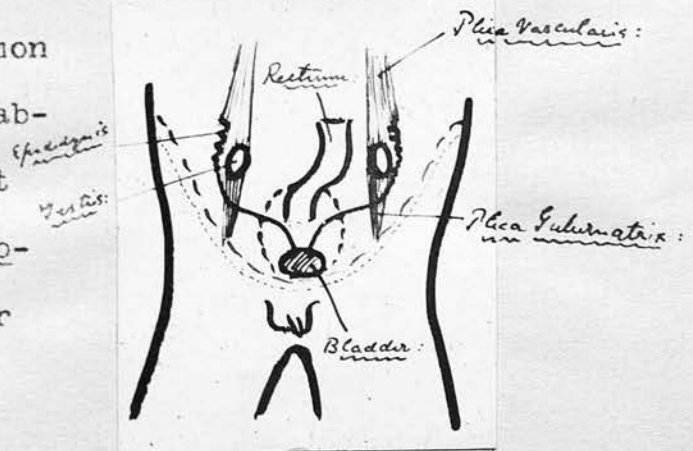
Economy he published an article entitled "A Description of the situation of the testis in the foetus, with its descent into the Scrotum."

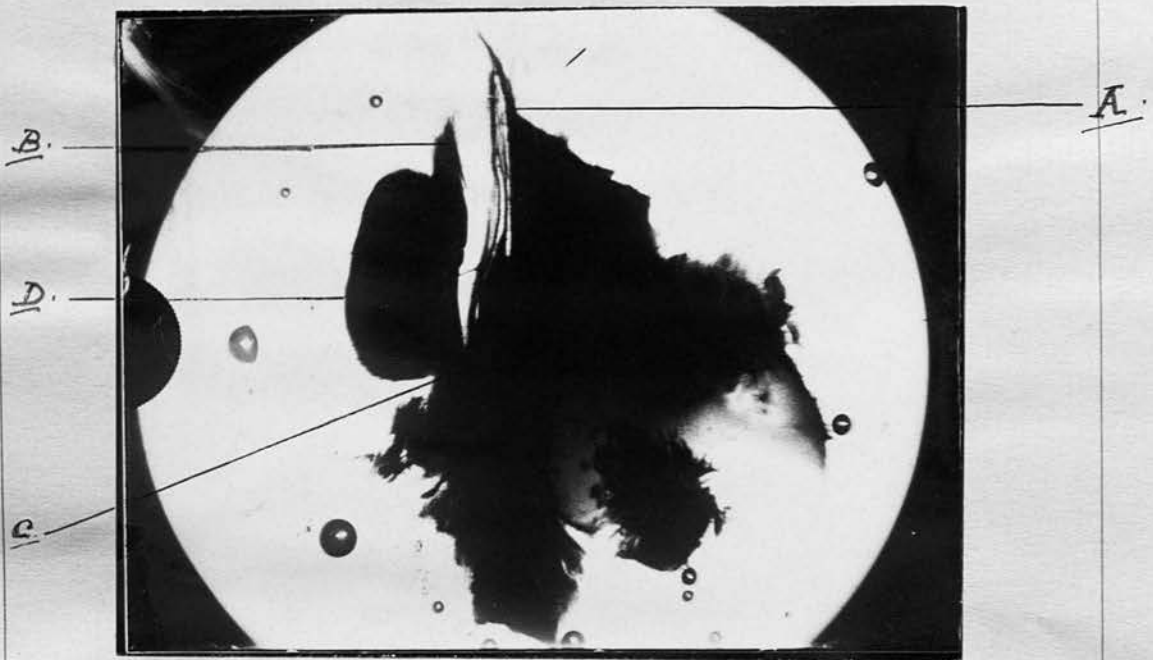
Previous to Hunter, Haller, in 1755, carried out some observations upon the matter.

In this country the observers whose names are best known are ~~these~~ Cleland, Sir Ashley Cooper, Hill, Keith, Lockwood, Owen, Robinson and Berry Hart. Upon the Continent their names are legion. They include such as Van Brock, Eberth, Frankl, Klastsch, and Weber.

If one reads the ordinary Text Book account of the descent, one gets an idea something like this:- The first two months of embryonic life are occupied with the development of testis and epididymis as individual organs; the former being developed from the genital ridge and the latter from the Wolffian body.

During the third month of Foetal life the testis and the epididymis come to lie side by side upon the post wall of the iliac fossa. Although both possess distinct mesenteries, the one combines with the other to form a common attachment to the posterior abdominal wall, this attachment being known as the Common Uro-Genital Ligament. The upper part/





Section in long axis of testes to shew attachment.

- A. Post Abdominal Wall.
- B. Plica Vascularis.
- C. Plica Gubernatrix.
- D. The Testes.

part of this ligament, where it extends along the post abdominal wall, is called the Plica Vascularis; the extension below the testis is known as the Plica Gubernatrix or Inguinal fold.

At this period there is no trace to be found of an inguinal canal, in fact the various layers of the abdominal wall are still intact.

At the fourth month the Gubernatrix begins to expand and forces its way downwards against the anterior abdominal wall towards the scrotum, which at this period is merely a pouch of subcutaneous tissue. The Gubernatrix finally forces its way through the abdominal wall, forming by its passage what is afterwards known as the Inguinal Canal. As it descends it carries with it a number of structures:-

- A. A Process of Peritoneum, (Processus vaginalis).
- B. Several Layers of Fascia which later become the coverings of the cord.
- C. A Layer derived from Scarpa's Fascia.

Keith in his Embryology, p.154, talking of the Gubernaculum, says "It will thus be seen that the Gubernaculum Testis is an actively growing mass of fibro cellular tissue which, starting from the muscular structures of the mesorchium and Plica Gubernatrix in the iliac fossa, invades the abdominal wall/

wall every layer of which it carries as a prolongation within the scrotum: it is an invading army of cells. It draws with it into the scrotum the peritoneum of the iliac fossa on which the testis is dragged like a log on a sledge."

During the 5th and 6th months the onward progress of the Gubernaculum and its accompanying structures proceeds.

During the seventh month of Intra-Uterine life the testicle is passing down the canal. By the eighth month it is passing through the External Ring, and in the ninth month it has reached the scrotum.

During the ninth month the processus vaginalis becomes occluded in two situations, above, at the Int. Ring, below, just above the testicle; the intervening portion becomes the obliterated Processus Vaginalis, - the lower portion - the Tunica Vaginalis Testis.

Such are the facts as any one may read them in a text book upon Anatomy or Embryology.

Berry Hart in a paper upon the subject, published in 1908, formulated certain facts which he says have hitherto been overlooked. They may be summarised as follows:-

- A. " That the Testes in the abdomen of the foetus are not covered by peritoneum but by Germ Epithelium."

B/

- B. " That the testes are not extra-peritoneal in the abdomen after the Wolffian Bodies have involuted, but have a distinct mesentery, in man developed from the diminished Wolffian structures.
- C. In the Scrotum the testes are not covered by peritoneum. If they were, the peritoneum would strip off as it does from a tumour such as the Epoochorite, developing in the Broad Ligament.
- D. The testes in the scrotum are really covered with involuting Germ Epithelium as the ovary is.
- E. However the human testis gets into the scrotum, their route is via the processus vaginalis, into the tunica vaginalis, and thus the the process becomes obliterated."

The development of the Inguinal Canal he has investigated by a number of serial sections of two human embryos (5th & 6th to 7th weeks). He summarises his views as follows:-

"There is thus complete evidence that in the human embryo, prior to the passage of the testis through the abdominal wall, there is a preformed inguinal canal due to the passage of the Peritoneum, Gubernaculum, and transverse and oblique muscles, to the outer side of the Rectus, forwards and inwards towards the scrotum."

The/

The "Abdominal Changes in position of the Testis" he has traced from month to month: they do not require ^{detailed} description here. At the beginning of the 3rd month the testis lies about 1 m.m. from the Internal Abdominal Ring. At the beginning of the 7th month the real descent begins until at 7½ months the testes are in the Inguinal Canal. Two weeks later they pass beyond the External Ring.

In discussing the causes of the descent of the human testicle he, insists that "the growth and development of the canal and of the Gubernaculum, and not an actual descent of the testis must be considered the great factor."

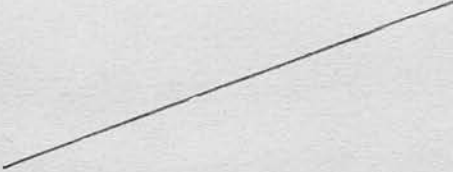
The question of Gubernacular traction he rather ignores, and he adds:-

"It (The unstriped muscle of the Gubernaculum) is not attached directly or even indirectly to the testis as the upper attachment of the ~~caudal~~ ligament is to the Epididymis and not to the testis."

Such is a brief synopsis of the views he has brought forward.

We shall now deal with our own observations, which were carried out upon a series of Human Foeti, ages varying from 2 months onwards. For a matter of convenience we shall divide our description into two/

two groups:-

- A. Macroscopic characters, dealing more especially with the gross and naked eye Anatomy.
 - B. The Microscopic and Histological aspect.
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D E S C E N T O F T E S T I S .

MACROSCOPIC CHARACTERS.

MACROSCOPIC CHARACTERS OF SPECIMENS AGED 2 MONTHS.

During our investigation we were fortunate enough to obtain specimens from practically all the Maternity Institutions in Edinburgh and Leith, the result being, that we had almost a unique amount of material at our disposal.

Each specimen was systematically examined and noted, and by following a definite plan we found that practically nothing was thus overlooked.

Only a simple dissection was necessary to expose the testis. The anterior abdominal wall was removed entire, and the abdominal contents thus exposed. Liver, stomach and spleen were then removed, the small intestines were thrown upwards and the mesenteric attachment separated; the large intestine was removed as far as the commencement of the Rectum; here it was cut through and removed, leaving the Rectum in situ.

In removing the abdominal wall the umbilical artery was divided and also the umbilical vein near its/

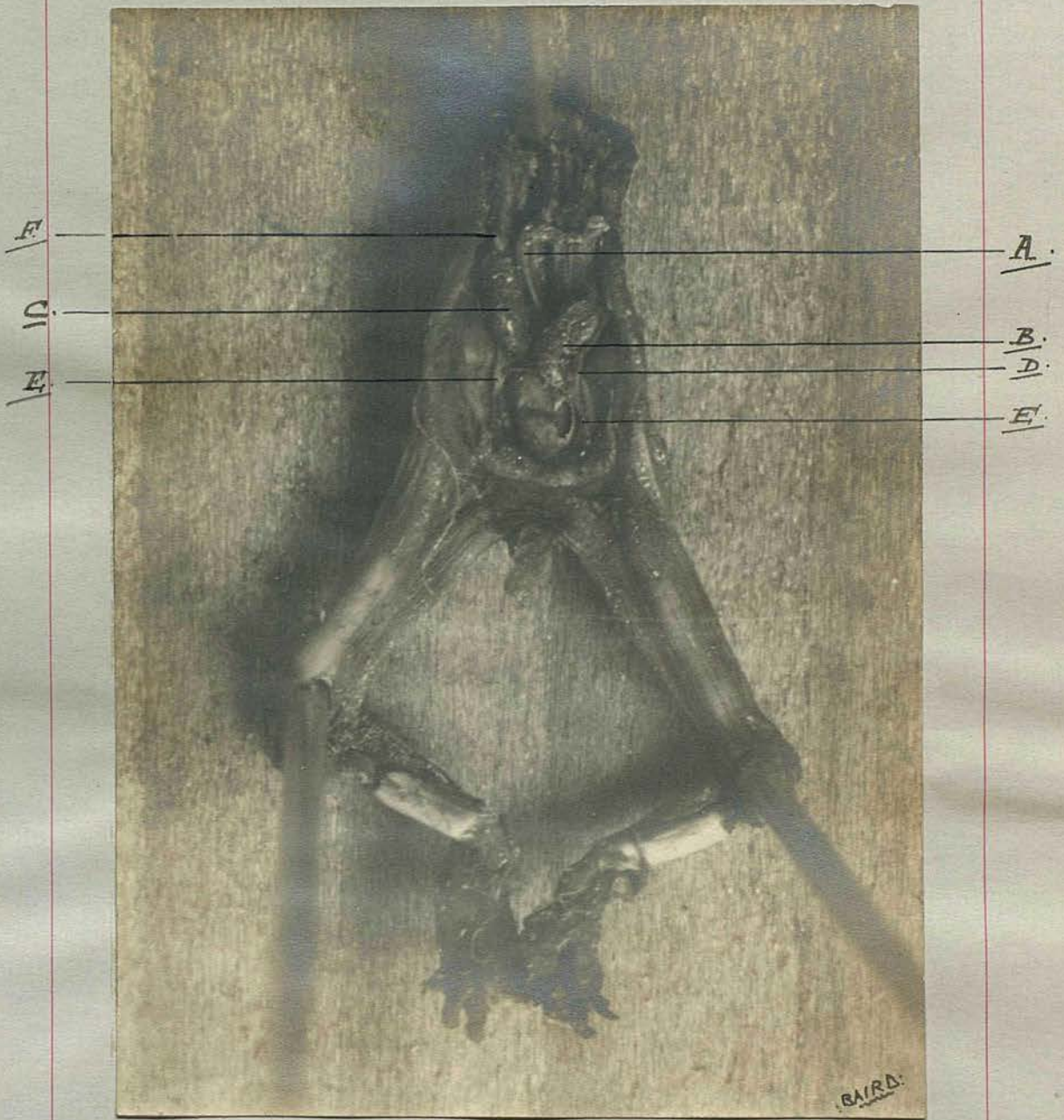
its entry into the liver - with such a simple mode of dissection, perfectly free access to the testis was obtained.

After the gross anatomy had been carefully studied and noted, the specimen was prepared and embedded in paraffin; the sections so obtained were stained and submitted to microscopic examination.

The earliest specimen which it was our good fortune to examine, was that of a foetus about 10 weeks old. The accompanying enlarged photograph shows the conditions present. The testis are seen lying one upon each side of the Vertebral column; the relatively high position which they seem to occupy is due to the fact that the photograph has been taken from above, - in reality the testis are lying upon the post. wall of the iliac fossa. The development from the Genital Ridge has reached completion, but traces of its existence are evidenced by a Basal constriction through which the testis is attached to the post. abdominal wall.

Immediately external to the testis, and better marked upon the left side, one can make out the Epididymis as a thin tubular process, slightly expanded above and below where the Globus Major and Minor are in formation.

At/



Dissections of 2 months foetus.

- A. Rectum.
- B. Left Testes.
- C. Right testis.
- D. Epididymis (Left.)
- E. Plica Gubernatrix.
- F. Plica Vascularis.

At this stage there is no trace of the Gubernaculum. The structure which attaches the testis to the post. abdominal wall is known as the Mesorchium: - the Genital part of the Wolffian Body - or in other words - the Epididymis - is also suspended by a mesentery, the Wolffian Mesentery; these two have a common superior attachment, the Common Urogenital Ligament, the upper part of which is known as the Plica Vascularis. In the testis of the right side this structure is well shown.

Testis and Epididymis are connected to the groin by a fold of peritoneum known as the Plica Gubernatrix or Inguinal fold; this also is very well shown in the photograph.

Along the inner and ventral aspect of the epididymis, but not shown in the photograph, lies the remains of Müller's duct.

At this stage of development, the feature of most interest is the great distance which seems to intervene between the lower pole of the kidney and the testicle. Originally the true kidney and the genital mass bear a very close juxta position, and at first sight it would appear that one or other organ must have undergone a marked alteration in position. In the rabbit's embryo this apparent rapidity of change in/
in/

in position is well demonstrated. About the 13th day the genital mass of the rabbit lies actually further forward than the true kidney and yet within the next 24 hours it has come to lie behind the middle of the Wolffian Body and consequently opposite the genital mass itself.

Upon which organ does the change in position depend? Kidney or Testis? - the kidney remains immobile in front of the Lumbar spine, but the testes also appears to maintain their original relationship to the cartilage of the Pelvis, and thus it comes about that the source of this apparent change of position lies in the lumbar spine, which, by the rapidity of its growth at this time, effects the wide separation between kidney and testis.

For our purpose, the state of affairs at this early stage of development is of little importance, the testes have shown no tendency to descend, and the processus vaginalis and gubernaculum are as yet unrecognizable.



Dissection of Foetus 2 - 3 months old.

- A. Kidney and Supra Renal.
 - B. Left testis.
 - C. Plica Vascularis.
-

The Second Specimen is that of a foetus $2\frac{1}{2}$ Months old.

Testis and Epididymis are distinct, lying upon the post wall of the iliac fossa. By comparison with a later stage, the testis and epididymis appear remarkably large. Between testis proper and epididymis, the differentiation is quite distinct, and there is a well formed digital fossa.

From the upper end of the epididymis, the top of the Globus Major, two well marked pedunculated bodies are recognised, the Hydatids of Morgagni; at this stage they retain an elongated appearance, showing their development from Müller's duct.

The Vas deferens is seen passing from the inner side of the testis, at the lower end of the Globus minor - curling round the ureter and disappearing into the Pelvis.

Passing from the upper end of the testis along the post abdominal wall, can be seen the remains of a well marked fold of Peritoneum - the Plica Vascularis, in which the spermatic vessels were developed; from the lower pole of the testis a somewhat thicker and shorter fold passes downwards, ending by blending with the ~~Parie-~~ ^{parie-}tal Peritoneum - this latter is the Inguinal Fold.

Both the Inguinal Fold and the Plica Vascularis are the remains of the Common Urogenital Ligament.

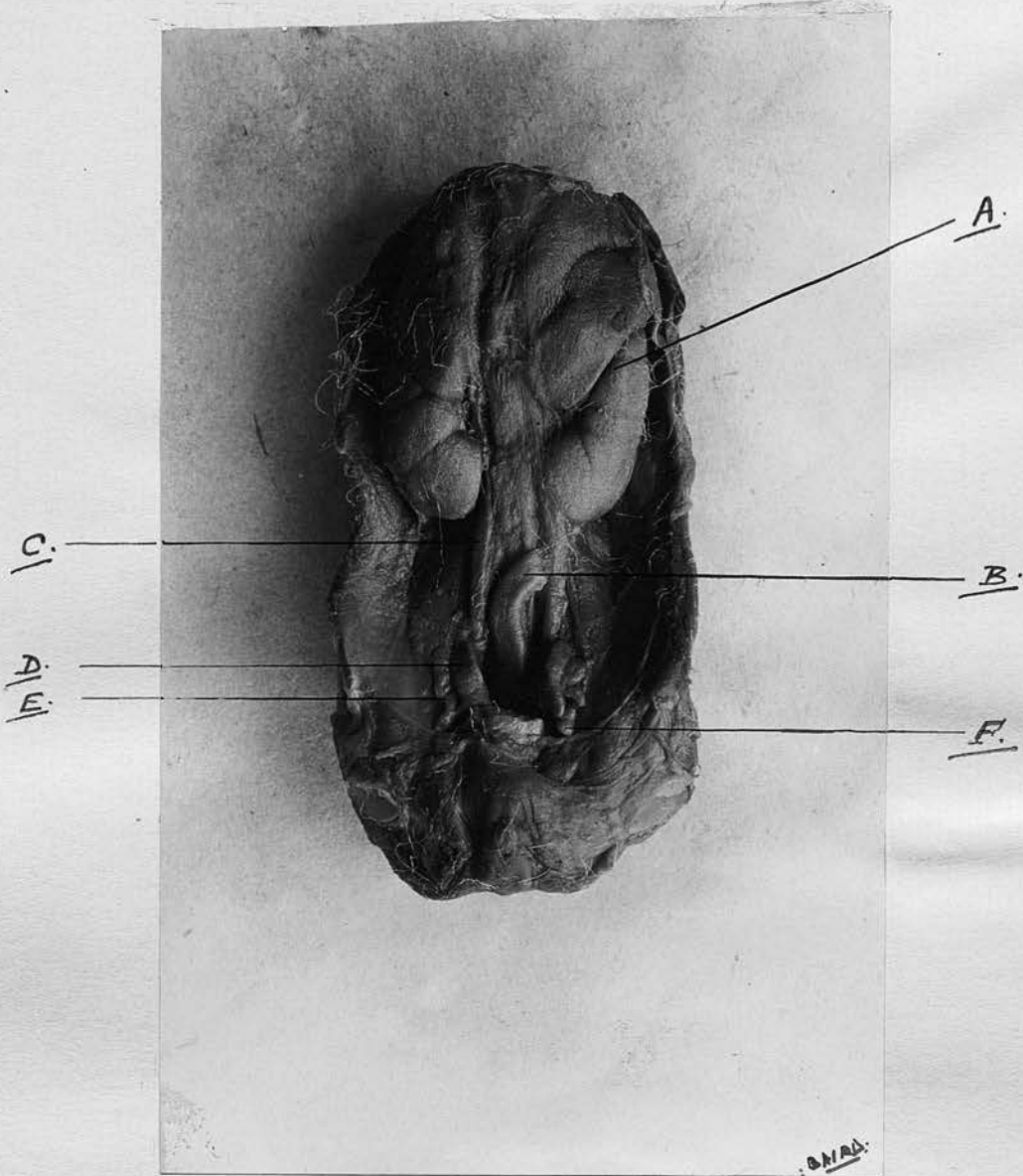
In this Photograph the testis has been removed from the right side in order to show better the Plica Vascularis/

Vascularis and the Inguinal fold. Upon the left side the testis remains still in place. The important point to note in this stage is, that there is still no trace of the formation of a gubernaculum as we shall show later when we describe the section. It will be seen that at this stage one cannot trace even the suspicion of such a structure.

The next specimen has been obtained from a foetus 3 Months old. The same method of procedure in dissection was adopted. Testis and epididymis occupy the same position upon the post abdominal wall; the Plica Vascularis is much less distinct, its place being occupied by well developed spermatic vessels. Curiously enough the testis appear to have undergone a certain amount of atrophy, when compared with the size of the testis in the earlier specimens. We shall show that this atrophy of the testis proceeds progressively until the testis has actually passed through the Internal Ring. It is of course quite a natural procedure, being really an attempt to diminish the size of the organ as much as possible, before it undertakes its journey through the abdominal wall. - This however is by the way. - The important feature of this stage is the changes which have taken place in the Inguinal fold; changes which are premonitory to the formation of the Gubernaculum. Just where the inguinal fold joins the lower pole of the testis the fold has undergone a most remarkable thickening/

thickening - so marked has been the change that the upper end of the Inguinal fold is now a rounded, almost circular swelling, equal in circumference to the Epididymis. The lower end of the Inguinal fold is not nearly so thickened, but it has formed a wider connection to the abdominal structures than was seen in the preceding specimen. This wider attachment is well demonstrated by pulling the testis gently upwards; there is an immediate response in the muscular strata of the abdominal wall.

The meaning of this thickening in the Inguinal fold we shall discuss later, sufficient for the present to say that it is introductory to the formation of a proper Gubernaculum, and that Histologically the thickening is characterized by a very active formation of fibro-cellular tissue.



Dissection of foetus 3 - 4 months.

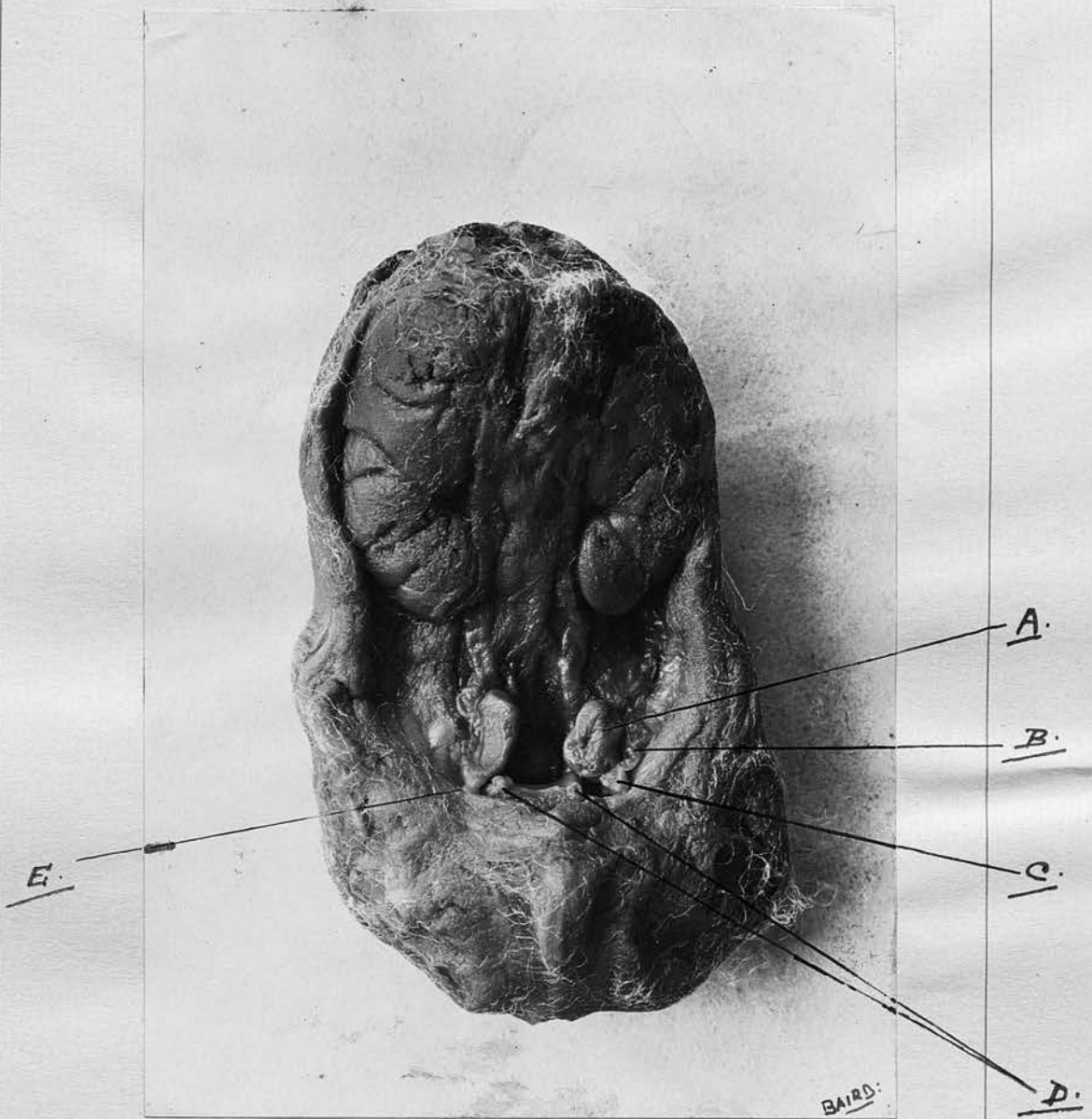
- A. Kidney and Supra Renal.
- B. Rectum.
- C. Ureter.
- D. Testis.
- E. Epididymis.
- F. Thickening at lower border of Epididymis preparatory to the formation of the Gubernaculum.

NOTE. As yet there is no trace of the formation of the Processus.

The 4th specimen illustrates the state of affairs in a 4 Months foetus. The general features are similar to those in the previous two specimens. The testes occupy similar positions perhaps at a slightly lower level. It is worth noticing that the vascularity of the organ has increased; the vessels of the spermatic plexus are larger and more distended than was previously the case.

We consider this increased vascularity important, pointing as it does to an increased functional activity of the organ; this functional activity being really the formation of the Gubernaculum testis; The quondam inguinal fold has undergone an unrecognisable change, it is now a short, broad band, nearly as thick as the body of the testis, it unites the testis to the abdominal wall, and at this date, - the 4th month, - has distinctly invaded the abdominal muscles; it is now a bundle of extremely active fibro cellular tissue, and its invasion of the abdominal wall is just proceeding. Our interest, of course, centres more upon the formation of the Processus Vaginalis, and here we see the earliest trace of it. Upon the right side there is just a commencing involution of the Peritoneum forming around the gubernaculum a fossa lined by peritoneum/

peritoneum about $\frac{1}{30}$ " in depth. This fossa does not extend completely around the gubernaculum, only around the anterior $\frac{3}{4}$, posteriorly the gubernaculum is adherent to the post. abdominal wall. Though the invagination of the peritoneum is just commencing, the advancing extremity of the gubernaculum has reached a considerable distance through the abdominal wall.



Dissection of Specimen 4 months old; shewing upon the Left side, the earliest formation of the Processus, in the shape of a small dimple surrounding the Gubernaculum.

- A. Testis.
- B. Epididymis.
- C. Gubernaculum.
- D. Umbilical Arteries.
- E. Early formation of Processus Vaginalis.

The attachment of the gubernaculum is in relation to the umbilical artery, it passes downwards immediately to the outer side of the artery, and immediately behind the attachment which the umbilical artery has to the peritoneum.

The next specimen was taken only a few weeks later and it demonstrates the extraordinary rapidity with which the gubernaculum now grows.

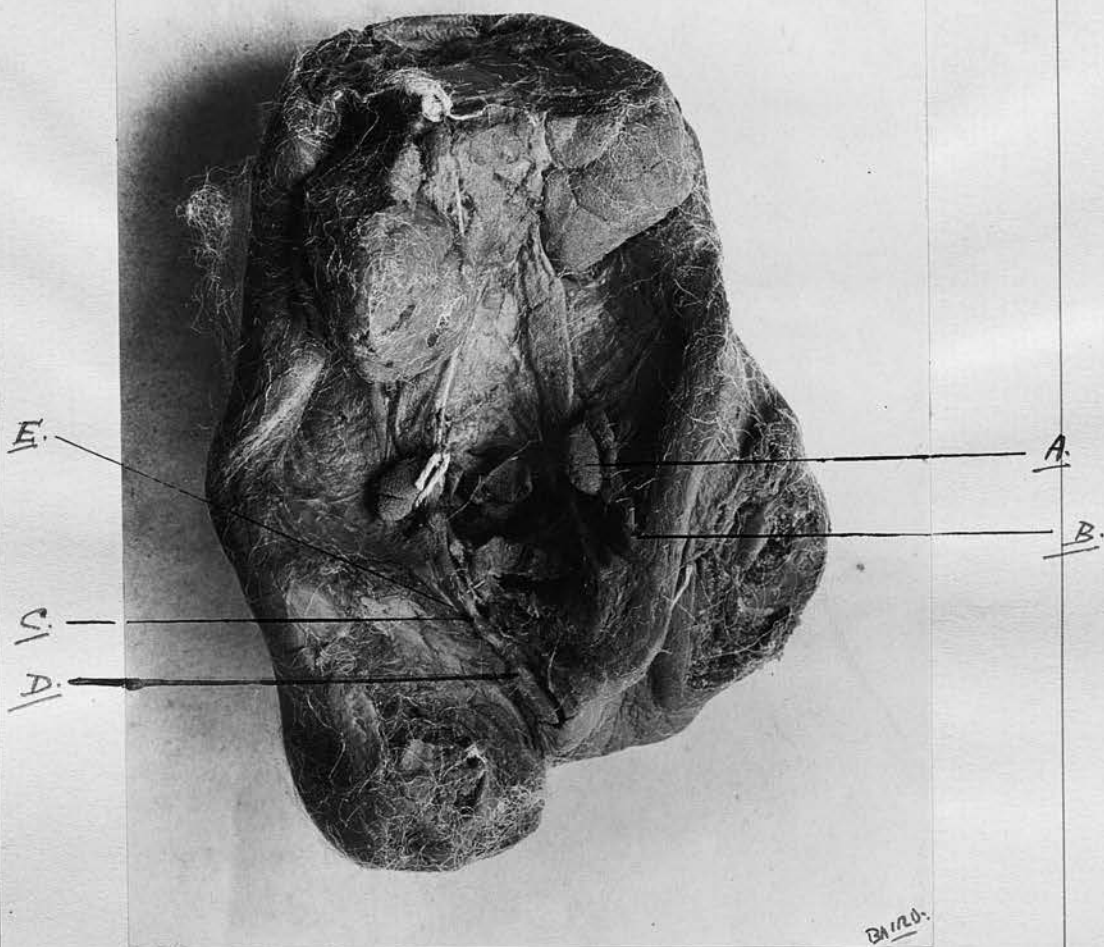
Upon the left side, the testis has not been disturbed and one sees very prettily the distinct pouching of the peritoneum, which, by its invagination, has formed the beginnings of a Processus Vaginalis. Upon the ~~right~~ right side, the Processus has been opened up in order to demonstrate the gubernaculum. It can be seen passing downwards behind the processus.

Just beyond the Muscular strata of the abdominal wall the process has stopped short, the gubernaculum has outgrown it, the fibres of which are shown passing downwards and inwards to the Symphysis Pubis. At this time the only attachment which the gubernaculum has formed is to the symphysis pubis - this is its first attachment.

In observing the foregoing specimen, we noticed that, during the 3rd, 4th and 5th months the testes remained in a practically constant position; they showed no tendency to descend. This feature was so striking/

striking that an explanation seemed necessary. Such an explanation is to be found in the fact that during these months the Gubernaculum has not reached any fixed point. We are firmly in agreement with the view, that the Gubernaculum exerts traction action upon, and naturally assists in, the descent of the testis, but only during the last 3 months. Until the 5th month has elapsed the Gubernaculum is merely a fibro-cellular bundle, burrowing in the tissues, and searching for some fixed point into which its fibres may be inserted. During the latter end of the 5th month such a point is reached in the shape of the Symphysis Pubis. The Gubernaculum has now the acquirements which a traction muscle requires, namely two fixed points, above it is attached to the Testis, below to the Symphysis Pubis; and, as we shall show later, at this period the Gubernaculum possesses in its composition the presence of both striped and non-striped muscular fibres; this is a point of great importance. The muscular tissue is true to its characteristics and contracts, the result being, that the least fixed point yields - in this case, the Testis.

Such is the reason, why, during the 2nd, 3rd, 4th and 5th months the testes remain in a practically constant position, and why during the 6th and 7th and succeeding/



Dissection of Specimen 4 - 5 months. Upon the left side the upper extremity of the Processus vaginalis is well seen. Upon the Right side the Gubernaculum has been dissected out as it passes downwards to the symphysis pubis.

- A. Testis and Epididymis.
- B. Upper orifice of Processus Vaginalis.
- C. Right Gubernaculum dissected out.
- D. Insertion of Gubernaculum into Symphysis Pubis.
- E. Lower end of Processus Vaginalis.

succeeding months they acquire such a marvellous rapidity of descent.



This photograph is one of the first which shows the extent of the Processus Vaginalis. In the previous photograph we saw the beginning of the process in the shape of a small circular fossa lined by Peritoneum and surrounding in part the gubernaculum.

We now see it as a distinct elongated tubular process of peritoneum which, when opened up, is found to extend almost half way along the tract of the gubernaculum, chiefly upon its anterior aspect.

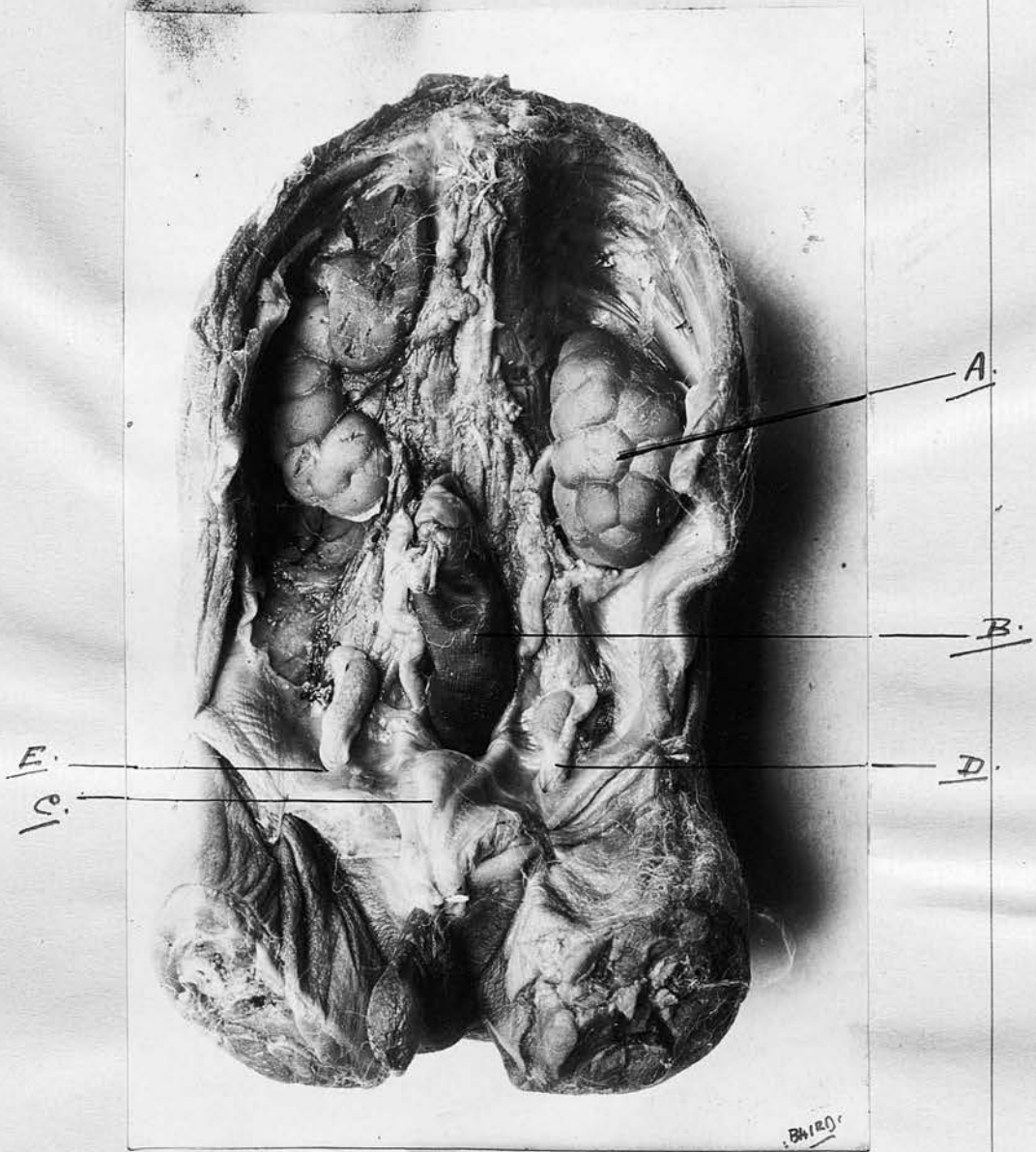
The gubernaculum precedes the formation of the processus vaginalis by quite a considerable distance; and one might arrange the organs as a sequence. First, the Gubernaculum; secondly, the Processus Vaginalis, and finally, the Testis and Epididymis.

The two former are precursors and preparers for the descent of the last but most important organs; the Gubernaculum we have shown in the later months of foetal life as a true attractor of the testis.

The reason for the formation of the processus vaginalis has been the centre of much argument and debate. The testis is an organ covered by smooth peritoneum, or, as is more properly stated, by a Germ Epithelium. In the course of its development, it has to make its way through a variety of tissues in the abdominal wall and scrotum. Its way is partly prepared by the formation and descent of the gubernaculum; and nature has further aided its progress by introducing along the line of its descent a tubular process of peritoneum. (The method by which the Processus is formed we discuss later in the Histology, of/

of the part). The smooth lined testis has now got a kindred tissue lining its path, and behind the kindred tissue it makes a comfortable and rapid descent. This to our mind offers the second reason why practically the whole of the descent of the testis occurs after the 5th month. It is only after the 5th month has elapsed that the Processus Vaginalis acquires a proper formation.

The 5th photograph is practically similar to the 4th. Upon both sides the upper end of the Patent Processes is well seen. Beyond this the photograph presents no new feature.



Dissection of Specimen 5 months old; shewing well
the Gubernaculum and upper orifice of the Processus
Vaginalis. The testes are just beginning their true
descent.

- A. Polylobular foetal kidneys.
- B. Rectum.
- C. Urachus and Bladder.
- D. Gubernaculum.
- E. Upper orifice of Processus. (Internal Ring.)

During the 6th month of foetal life the active descent of the testis has begun, and we see the testes of both sides just disappearing through the rings.

An enlarged photograph is added, and shows very prettily the upper end of the processus vaginalis, and how it extends around the anterior and outer aspects of the gubernaculum.

One cannot help noticing in this specimen how rapidly the testis has begun to descend. The organ which for three months or so has lain just at the internal ring, occupying a position which it seemed almost permanently to have taken up, has now begun a vigorous descent. In another part of this treatise we have drawn attention to this fact; for the nonce it is sufficient to say that in our opinion it depends upon the attachment of the gubernaculum to the symphysis pubis. This is the period at which the gubernaculum forms its first secure attachment, and having obtained this fixed point its muscular tissue fulfils its function by contracting and drawing the testis downwards.



Dissection of Specimen at 6 months to shew testis
just disappearing through the Internal Ring.

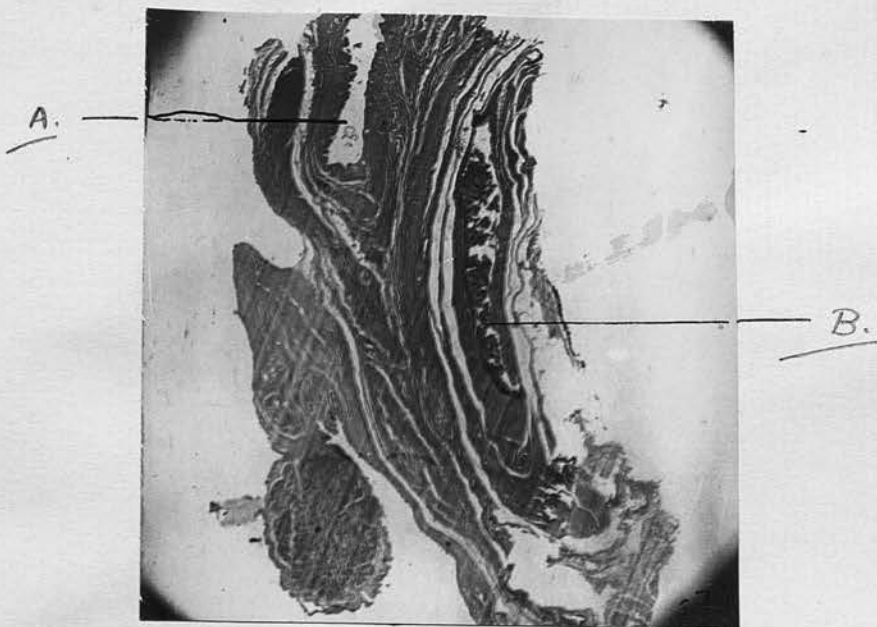
- A. Testis.
- B. Internal Ring. (Processus).
- C. Bladder.



Similar Specimen. (Enlarged)

Finally there is one point which requires to be mentioned. If we compare the conditions at the 5th month with those at the 6th month, we see that the upper aperture of the Processus Vaginalis, which afterwards becomes the Internal Ring, undergoes a considerable change. At the 5th month the Processus surrounds the Gubernaculum with the exception of a narrow portion lying posteriorly; but, as the 6th month approaches, the Gubernaculum forms a wider Postero-Internal attachment to the Parietes, while the Processus is correspondingly limited to the Antero-External aspect. This change is merely preparatory to the later obliteration of the Processus.

The following diagramatic sketch represents the state of affairs at this stage; the gubernaculum is represented in vertical section; lying immediately in front of it there is the patent processus descending into the bottom of the scrotum.



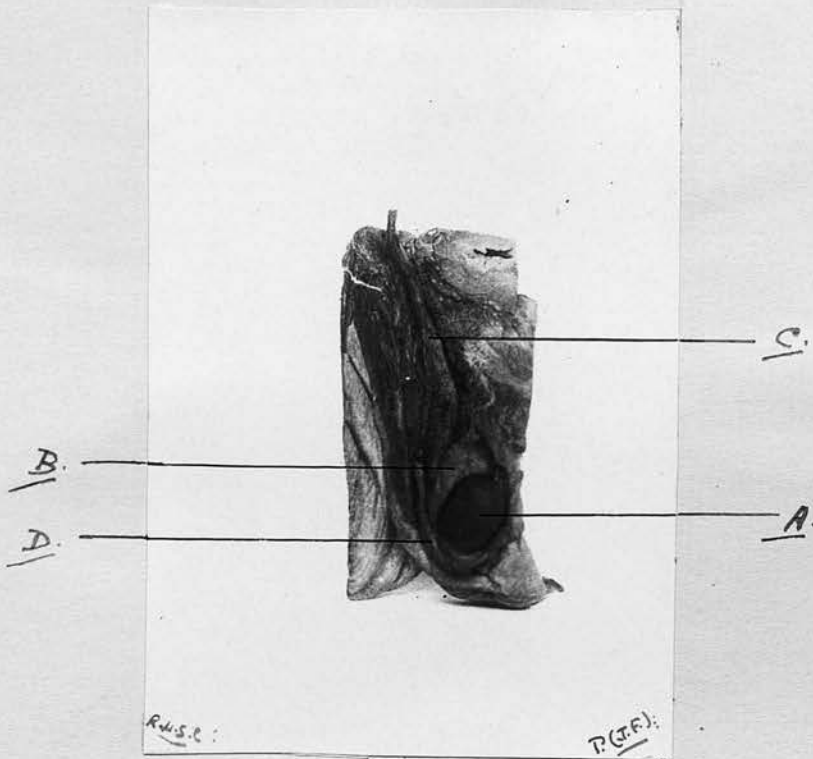
Photograph to shew the descent of the pouch,
anterior to the descending Gubernaculum. The two,
however, are coming into close contact.

A. Processus Vaginalis.

B. Gubernaculum.

The testis spends the 7th month of foetal life in its passage through the abdominal wall, and in the 8th month it leaves the Inguinal canal and lies at the Ext. Abd. Ring. The general anatomy of the part is similar to that described in the former month. The gubernaculum has begun to involute, and now appears as a thin sheet of muscular tissue, extending along the post line of the cord and extending in a fan-like fashion from the symphysis pubis to the fundus of the scrotum. The testis shows a most interesting condition in the shape of considerable haemorrhage within its substance; the testis itself is often quite black, while the epididymis and surroundings are variously infiltrated with blood. This fact gives an important clue to the causation of the descent of the testis beyond the internal Ring.

We have traced and shown some reasons for the descent of the testis as far as the Internal Ring, but now we are met with this difficulty, that it is unlikely that the gubernaculum can help its descent any further. It has undergone considerable atrophy, showing that its function is gone, and moreover its attachments are such, that it is difficult to see how it could possibly aid the further descent of the testis.



Dissection of Specimen 7 - 8 months old. The testis has just passed through the external ring.

Note the extreme congestion and actual extravasation of Blood which has occurred.

- A. Congested testis.
- B. Epididymis.
- C. Cord.
- D. Reflection of Processus vaginalis.

The lowermost fibres may perhaps aid its descent to some extent; we are however inclined to believe that a stronger cause must be looked for elsewhere.

The Haemorrhage and Extravasation of Blood in the testis is the clue to which we attach most importance. This haemorrhage has obviously been the result of considerable pressure which has been exerted upon the testis in its descent through the muscular elements of the abdominal wall. Now such pressure could not have been exerted upon a small rounded body like the testis, without influencing its movement one way or another. It certainly would not have given rise to any ascent of the testis, and the natural conclusion is that the interlacing muscular arrangement of the canal has by its contraction greatly stimulated the testicular descent.

Keith, (Human embryology and morphology), p. 155, says "The atrophy of the gubernaculum pulls it down."- An atrophying tissue is one which has lost its function, and it does not contain sufficient fibrous element to permit the descent to be due to a fibrous contraction.

We have thus traced the descent of the testis as far as the end of the 7th month, and its position now lies immediately below the external ring.

The 8th and 9th months are occupied with the further descent of the testes and the commencing involution of the processus vaginalis.

At the 8th month we find the testis lying at the External Abdominal Ring, and we have shown the important features which occur during the progress of its passage through the Inguinal Canal.

During this and the following month the position of the testis does not alter greatly. There is a slight descent, the main ongoing change being found in the gradual obliteration of the processus vaginalis testis.

At 7½ months the processus vaginalis is completely and perfectly open; but from the 8th to the 9th month the process of obliteration proceeds by leaps and bounds.

The occlusion is first noticed in the situation of the Internal abdominal ring and in that part of the processus which corresponds to the inguinal canal.

In another part of this article we have stated what we consider the reason for the formation of the processus vaginalis, namely that the introduction of its smooth serous cavity renders easy the passage of the testis through the closely knit muscles of the abdominal wall.

When/

When the testis has passed through the abdominal wall, and the most hazardous part of the journey has been completed, the processus vaginalis is no longer a necessary feature in the economy of nature; it becomes an effete structure, with the result that nature takes care that its disappearance is manoeuvred as rapidly as possible.

We have said that the occlusion takes place most commonly at the ~~internal~~ abdominal ring, or the portion which corresponds to the inguinal canal; and we have the authority of Keith in saying that in 30% of cases the occlusion occurs at the internal ring after birth. There is another common situation of occlusion, and that is the point just a short distance above the testicle.

The part of the processus vaginalis between the points of occlusion is known as the "funicular process," and its atrophied remnant is found in adult life as a fine white fibrous strand intimately bound up with the structures of the spermatic cord.

Having satisfied ourselves why the processus vaginalis descends, and why it later disappears, we must next ask ourselves, What is the method of its disappearance?

By far and away the most common situation in which occlusion/



Specimen to shew the commencing occlusion of
the Processus Vaginalis.

- A. Point of Occlusion corresponding to Internal
Ring.
- B. Point of Occlusion immediately above testis.

occlusion begins is the ^{internal} ~~interior~~ abdominal ring, and this feature gives one the key by which the remainder of the problem may be solved.

The internal abdominal ring indicates quite the narrowest part of the processus vaginalis, and as the testis descends through the internal ring behind the patent processus, the pressure which the testis suffers, is shared in part by the processus vaginalis.

We have shown how the testis suffers from this pressure to the extent of actual haemorrhage. The effect upon the processus vaginalis is the production of a simple inflammation of the serous membrane which lines the patent process - in other words a simple plastic peritonitis. This inflammatory change, occurring in two serous surfaces in actual contact, results in the formation of adhesions and the actual obliteration of the Lumen of the Processus.

It is only a question of time for these changes to become general along the whole length of the processus; failure to close at one or other point may of course occur, and closure at two points with an intervening patent processus often results in the formation of what is known as a Hydrocele of the Processus Vaginalis. No constant time can be given at/

at which this closure begins to occur; we have noted it at different periods, as early as the 7th month, and of course its permanent delay is the main factor in Congenital Inguinal Hernia.

There is yet another question which we have to consider. What is the fate of the Gubernaculum?

It undergoes a progressive atrophy, and at the beginning of the 9th month extends along the posterior aspect of the Processus and Cord as a fan-like radiation of fastly disappearing tissue.

At the lower pole of the epididymis there persists, for some time, a nodular mass of fibrous tissue, which indicates its former attachment.

It is after the 9th month that the testicles actually complete their descent into the Fundus of the Scrotum. It is difficult to state what is the actual cause of the completion of ~~their~~ journey.

Charles Robin, writing in the Paris Medical Gazette of 1849, says "Arrived at the exit of the Inguinal Canal the organ finishes its descent into the scrotum, either by the pressure of the viscera, or by its own proper weight."

Let us now recapitulate and summarise the chief points to be noticed in the naked eye appearances of the testicular descent.

Months 1 and 2,

Are occupied with the development of the testis from the genital ridge and the epididymis from the Wolffian body. It is important to note the apparent descent of the testis in its differentiation from the kidney, and how the apparent descent is really due to a rapid growth in the lumbar spine. The actual changes which result in the development of testis and Wolffian body are dealt with under the heading of Microscopic Characters.

This stage of development, as we have already said, is not of great interest for us, but in a dissertation upon the descent of the testis it cannot very well be omitted.

There is one other point noticeable at this time to which we would draw attention - the comparative size of the testicle. This fact, together with its early development and specialization, would indicate that at this stage it played an important part in the economy of the embryo, quite distinct from its later sexual function.

3rd/

3rd to 4th months.

There is something fascinatingly interesting about this period. It marks the commencement of that stage around which our interest specially centres. The position of the testicle has not altered, but the former Inguinal fold is now the Gubernaculum. Its upper attachment is quite definite to the lower pole of the Epididymis.

The Plica Vascularis at the upper pole of the testis has disappeared.

It is well to note how the development of the Gubernaculum is not a simultaneous change throughout its whole length, but that it is a distinct development from above downwards as though there were a gradual collection of energy at the upper pole ready to burst like some great wave along the length of the fold.

The later portion of the 4th month finds the development of the processus well on its way; the gubernaculum, its fore-runner, has advanced a considerable distance in its invasion of the abdominal wall, and the processus has followed hot-footed upon its steps - its exact method of so doing is discussed later. At present it surrounds quite $\frac{3}{4}$ of the circumference of the gubernaculum^m with
a/

a distinct fossa.

Especially must one notice that the position of the testis has not altered to any noticeable degree.

5th Month.

We attach great importance to this date for we have shown how it corresponds with the first real attachment of the gubernaculum to a fixed point. An indefinite groping by the advancing gubernaculum has found a resting place in the symphysis pubis, and, almost simultaneously, microscopical examination shows the commencing appearance of muscular fibres, striped and non-striped, in the substance of the gubernaculum. These conditions are but preparatory to the testicular descent; the demands of the laws of mechanics have been satisfied, a fixed point and a motive power have been obtained. The descent of the testis is a necessary consequence.

6th Month.

The testis has begun its true descent and at the 6th month is situated just at the orifice of the Internal Abdominal Ring. Its descent from this time onwards is very rapid and, as we have pointed out, depends in the main upon two factors:-

- A. The Fixation of the Gubernaculum to the Symphysis Pubis.

B/



- B. The appearance at this time in the Gubernaculum of a quantity of Muscular fibres, striped and non-striped.

7th Month.

The testis rapidly passes through the abdominal wall and by the end of the 8th month is appearing at the external ring.

A noticeable point of its descent is the extreme congestion to which the testis at this time is liable, the congestion at times amounting to actual extravasation of blood.

We hold that the passage of the testis through the abdominal wall is aided and abetted, by the contraction of the sieve-like arrangement of the abdominal muscles; which contraction, in addition to aiding the testicular descent, causes by its pressure, congestion in the testis and its addenda.

So far, therefore, we have touched upon three distinct changes which play a part in the physiological descent of the testis. They are:-

- A. The Growth of the Lumbar Spine causes the first stage of the apparent descent. Kidney and testis become widely separated - not from any actual change in position of either of these organs, but because the disproportionately rapid growth/

growth of the lumbar spine causes a gap to appear between the different organs.

B. The Traction influence of the Gubernaculum coming into play only after the 5th month.

C. The muscular action of the abdominal wall closing upon the testis and forcing it downwards as far as the external ring.

The 8th and 9th Months.

These months are occupied with the completion of the testicular descent.

The Gubernaculum atrophies and the Processus Vaginalis as a patent process becomes obliterated.

The obliteration of the processus vaginalis is the result of a certain degree of foetal Peritonitis which is secondary to the congestion and irritation resulting from the passage of the testis through the abdominal wall.

DESCENT OF TESTISMICROSCOPIC CHARACTERS.

Microscopical examination, of course, affords the most fertile source of our information, and by its study one may elucidate points which hitherto seemed puzzling.

The plan and method of our examination has already been given.

To study the microscopical characters and process of development of the testis and epididymis, in the early human embryo, is almost impossible. It is hard to estimate exactly the age of an early embryo, but one which is apparently 23 days old may be compared in size to a small house-fly. Yet in such a tiny specimen one finds that the Wolffian body and Genital Ridge are already fully developed.

The embryos of chicks and rabbits are therefore most commonly used in the investigation.

DEVELOPMENT OF TESTIS & EPIDIDYMIS TO SECOND MONTH.

As a more or less specialized organ the testis exists in all vertebrata and also in some of the higher forms of invertebrata. As we ascend the scale of development we find that in Mammalia it tends to migrate from the scene of its development and pass towards the inguinal region. In the highest of all vertebrata, with which we class man, we find that the testis undergoes a normal migration, leaves the confines of the abdomen, where it was developed, and, after passing through the abdominal wall, finds a final resting place in the scrotum.

The testis consists of two parts, the testis proper and the epididymis, and these are distinct both in their origin and in function.

The testis is developed from the mass of cell tissue known as the genital ridge; the epididymis proper is developed from the Wolffian body. Again the testis is the real formative gland - the epididymis is a complicated arrangement of the excretory ducts of the former organ.

The genital ridge or eminence is seen at an early period of embryonic life as an elevation on the mesial side of the Wolffian body. This ridge is covered with germ/

germ epithelium from which the generative elements are afterwards developed.

When the genital ridge is microscopically examined it is found to consist of two distinct types of cells: - A. A number of large branched cells, the processes of which join to form a Reticulum.

B. A number of smaller unbranched cells with deeply staining rounded nuclei which lie within the space of the reticulum.

Lastly, there is a loose fibrous stroma which is, in places, continuous with the stroma of the Wolffian body. The genital ridge is different from the Wolffian body in this important peculiarity, namely, that from a very early date it contains blood vessels.

The peritoneum which lines the Pleuro-peritoneal cavity of the embryo is covered with a uniform layer of cubical cells, but as one traces the layer inwards to the genital ridge one finds that when it comes in contact with the ridge it alters somewhat, and the uniform cubical endothelium has become changed into a conglomeration of cells of all sizes and types, large and small, oval, cubical, or columnar.

Until the 5th week of intra uterine life, the genital ridge is such a mass of cells as is here described. One must remember, however, that the whole length of the genital ridge is not used in the formation/

formation of the testis, but only that portion which lies opposite the 10th, 11th and 12th Dorsal Segments.

After the 5th week, this portion of the genital ridge undergoes changes which result in the formation of the testis proper; - solid columns of cells, probably in-growths of germinal epithelium, are seen coursing through the gland. These columns are the early stages of the seminiferous tubules, becoming afterwards hollowed out. The Tunica Albuginea is formed from the mesoblastic covering of the genital ridge. The visceral layer of the Tunica Vaginalis is formed by the covering of germinal epithelium.

THE EPIDIDYMISS.

"The embryonic connective tissue which participates in the constitution of the Wolffian body is found on either side of the primitive structure running along the greater part of the length of the embryo and occupying a position at the posterior part of the Pleuro-peritoneal cavity." Eccles. 1903.

In lower vertebrata the Wolffian body is the true functional kidney; in higher vertebrata it is merely a temporary or embryonic structure, which later disappears or remains as a vestige.

It reaches its maximum development at the beginning/

beginning of the second month of foetal life; by the end of the month it has become vestigial.

It projects as a ridge from lumbar and dorsal regions, and to its inner side lies the above mentioned genital ridge. Each Wolffian body is built up of a multitude of cells, usually triangular in shape. These cells are arranged in more fully developed structures, as glomeruli, tubules and ducts.

The tubules are developed from the intermediate cell mass - of mesoblastic origin - the cell mass is composed of different segments, and two or three tubules arise from each segment.

The development of the tubules is briefly something like this:- the mesoblastic cells form minute vesicles in the substances of the intermediate cell mass; each vesicle becomes elongated and tubular. They constitute, when they are developed, definite channels of communication between the peritoneal cavity and the Wolffian duct, into which they respectively open.

The glomeruli appear at a later date than the tubules and seem to be developed by an invagination of the peritoneum, the invagination being caused by the pressure of a tiny vascular bud.

In/

In point of time, the Wolffian duct is of the three the first structure to be developed. Originally, it is represented as a solid mass or column of cells, possibly epiblastic, possibly mesoblastic, in origin.

Soon the mass of cells becomes hollowed out and demonstrates a change in its position. Originally found beneath the epiblast it now appears to glide ventral-wards, so as to lie immediately beneath the lining of the body cavity. The importance of this change of position lies in the fact that Wolffian duct and genital ridge are now in more direct relationship to one another. The lining of the duct was traced by Kollman from the overlying epiblast, but this view is open to question; though His & Henson have proved beyond doubt that in the chick this Wolffian duct is developed from an epiblastic invagination.

The tubules of the Wolffian body open into the Wolffian duct, which latter runs backwards and turns into the pelvis to end in the cloaca of the hind gut.

During the second month the epididymis reaches its full development, and by the termination of the second month only its vestiges remain. These vestiges consist in :-

- A. The tube of the epididymis which is coiled up in the/

the Globus major, body and globus minor of the epididymis.

- B. The vas deferens and the common ejaculatory duct.
The duct opens at each side of the uterus masculinus or sinus pocularis in the prostrate^{ic} urethra.
- C. The Vesiculae Seminales, which arise from the Wolffian ducts, as Acino-tubular diverticula.

The tubules of the Wolffian body become developed into portions of the testicular excretory system; the Rete testis, the vasa efferentia and the coni vasculosi are all formed from these tubules.

The Glomeruli form only two structures, occasionally one:-

1. The vasa aberrantia found in the globus minor.
2. The paradidymis or organ of Giraldes occasionally found in the cord above the globus major.

In the male, practically all the structures of the Wolffian body become utilized in the later development of the Genital System. In the female, upon the other hand, they remain functionless and are only of Pathological importance.

By the end of the second month testis and epididymis have reached a stage of development when each can be differentiated as actual organs.

3rd Month.

At the beginning of the 3rd month testis and epididymis are distinctly differentiated; they lie upon the post wall of the iliac fossa.

The plica vascularis is beginning to atrophy but the plica gubernatrix is still present. Just where it joins the testis, it shows the localized thickening which indicates the commencing formation of the gubernaculum.

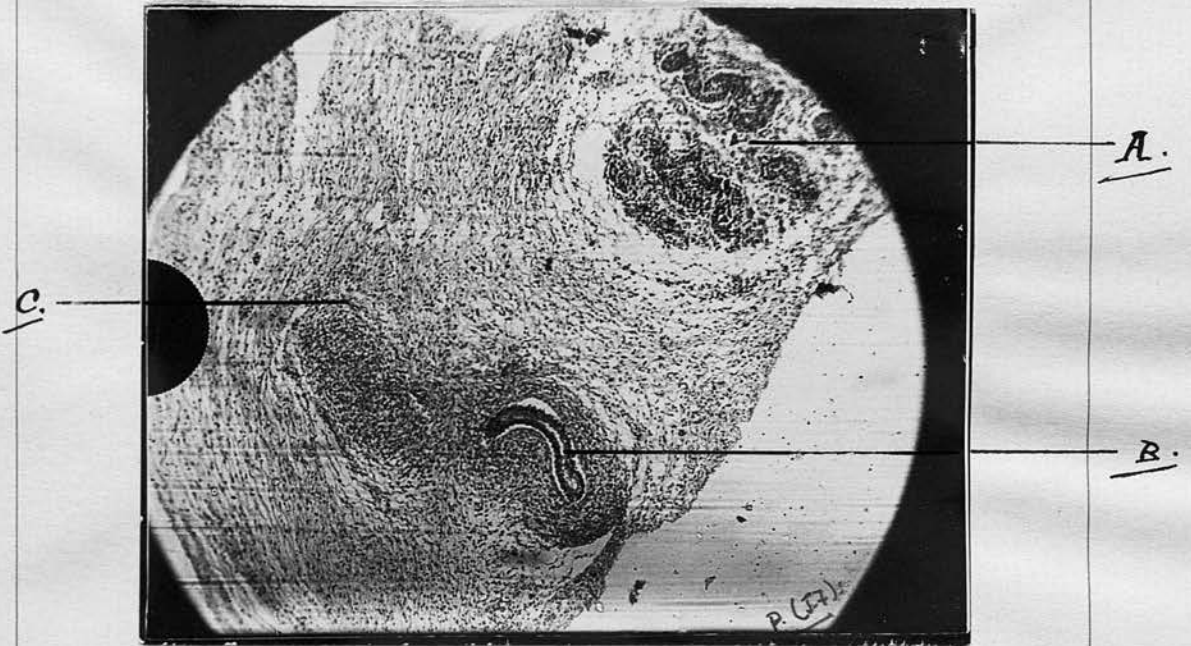
So much for the naked eye appearance of this period. The microscopic characters are as follows:-

3rd Month. Early.

Testis and epididymis are unaltered in position and by two sections we can arrive at an idea of the position of affairs.

The first section is taken through the upper end of the plica gubernatrix or inguinal fold, just where it joins the lower pole of the epididymis. A microphotograph showing the appearance under the high power gives one a good idea of the picture.

Clustering/



Microphotograph. Section in long axis of lower end of Epididymis - shewing the collection of fibro-cellular tissue at lower end of Epididymis from which the Gubernaculum arises.

- A. Epididymis.
- B. Duct of Epididymis.
- C. Collection of Fibro-Cellular Tissue.

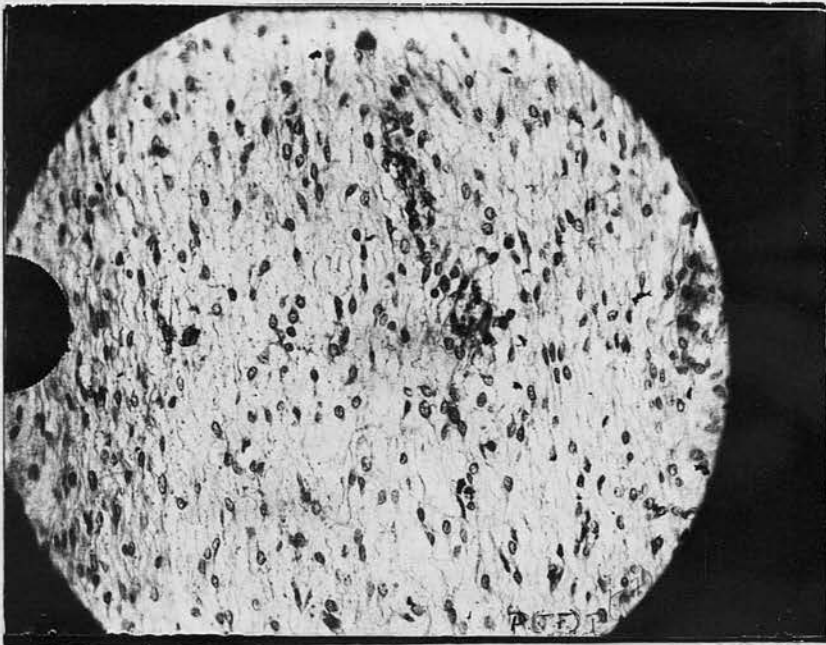
Clustering around the lower pole of the epididymis there is quite a collection of fibro cellular tissue. It is continuous with the lower pole of the epididymis and extends also for some distance along the post surface of that organ. It extends downwards as a thickened pillar, and as one traces it downwards it seems to taper off into a loose areolar mass. Its structure is simple and fibro-cellular in nature and apparently of an actively dividing and growing type. No blood vessels are apparent in its structure and most likely its nutrition is provided for by the lymph which at this period is very plentiful in this region; everywhere lymph nodes and sinuses are in evidence.

Minute examination of the fibro-cellular element shows two kinds of tissue:-

- A. Cellular, with large deeply staining nuclei and a comparatively scanty supply of protoplasm. The cells vary much in shape, some are round or cubical, the majority are elongated and oblong in type.
- B. Fibrous. One can scarcely term it a fibrous element, the actual fibres are short, the nuclei are indistinct and difficult to stain. Between the individual elements there is plenty of space, a fact which/

which distinguishes this early state of the gubernaculum from the fully formed article, in which the tissues are densely and firmly packed together.

This structure which we have been describing is the beginning of the formation of the gubernaculum, and it is first noticeable where the upper end of the plica joins the lower pole of the epididymis. Presently it will extend downwards replacing the inguinal fold completely and ending by an invasion of the muscles forming the abdominal wall.



Structure of the early Gubernaculum: loose
fibro cellular tissue.

At this stage the abdominal wall is ~~practically~~ entirely unbroken. Upon a long section the muscular fibres of the abdominal wall are noted. In the most superficial part they are covered by a loose cellular structure, corresponding to the ^{sub-}~~stula~~ - parietal - peritoneal tissue. The abdominal wall is entirely unbroken, but coming in contact with it immediately beneath the lower pole of the testis there is a fold of pillar of loose and very vascular tissue. This pillar contains firm fibrils of fibrous tissue, numerous round cells some of which are becoming myxomatous, and innumerable distended lymph and blood sinuses, probably the great majority being lymph sinuses. It is covered anteriorly and laterally by a continuation of the peritoneum with similar histological characters. There is absolutely no appearance of any invagination of the peritoneum, in other words there is no sign of the formation of the processus vaginalis. The loose myxo-cellular pillar is undoubtedly the fore-runner of the gubernaculum, not that at present it in the least resembles it, but we shall see later the transformation which is brought about.

In short, an examination during the early part of the 3rd month shows three important features: -

A/

- A. The commencing formation of the gubernaculum seen as an active formative^{ion} of the fibro cellular tissue around the lower pole of the epididymis.
- B. The continuation of the structure downwards as the inguinal fold or plica gubernatrix, the microscopical characters of which are a loose Myxo-fibro-cellular tissues.
- C. The as yet unbroken continuity of the abdominal wall.

3rd Month. Late.Microscopical Characters about 3rd Month.

Of this stage an excellent section has been obtained, showing beautifully the commencing invasion of the abdominal wall by the gubernaculum. The sections were serial paraffin ones, cut in the long axis of the advancing gubernaculum. Compared with the conditions described in the previous section, the gubernaculum being almost unrecognisable, it is now a strong thick fibro-cellular bundle which has ~~extended~~ as a pointed process among the abdominal muscles. It has pushed the ~~muscular~~ muscular bundles aside and its top is surrounded by loose areolar tissue which shows a considerable quantity of fat in its meshes. The blood vessels are thickened, and it would seem that an endarterⁱitic obliterating change in the vessels was a preparation for the advancement of the gubernaculum, the immediate result of the vascular change being a lessened blood supply with a resulting fatty degeneration of the tissues usually supplied by the blood.

Probably the pressure of the advancing gubernaculum also plays a part in the degenerat^{ive}~~ion~~ changes surrounding the gubernaculum.

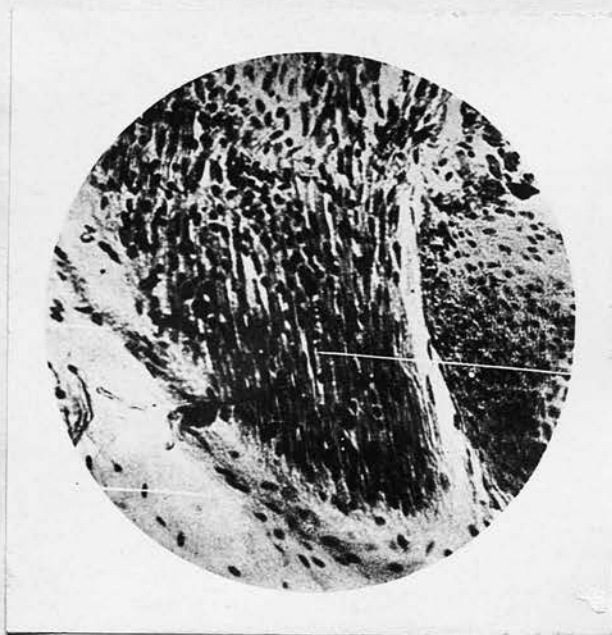
The minute structure of the gubernaculum ~~is~~ not what we have already indicated, namely a fibro-cellular/



cellular bundle, rich in cells. It has become wonderfully vascular, this vascularity being an important difference from the early gubernaculum of the previous section.

It is still rich in cells, the fibrous tissue has hardened up considerably, and altogether the structure of the gubernaculum has become denser. Still more important, there is now beginning to appear in its structure, a few bundles of unstriated muscular tissue.

This advancing gubernaculum has begun its invasion of the abdominal wall by the insertion of a wedge-shaped cone of its fibro-cellular element, which displaces and replaces the original muscular tissue. We have mentioned the tissue changes which precede the gubernacular advance, an ^{ri}endarteritic and obliterating condition of the blood vessels, an atrophy and in fact a/



The Invasion of the abdominal wall by the Gubernacular
wedge.

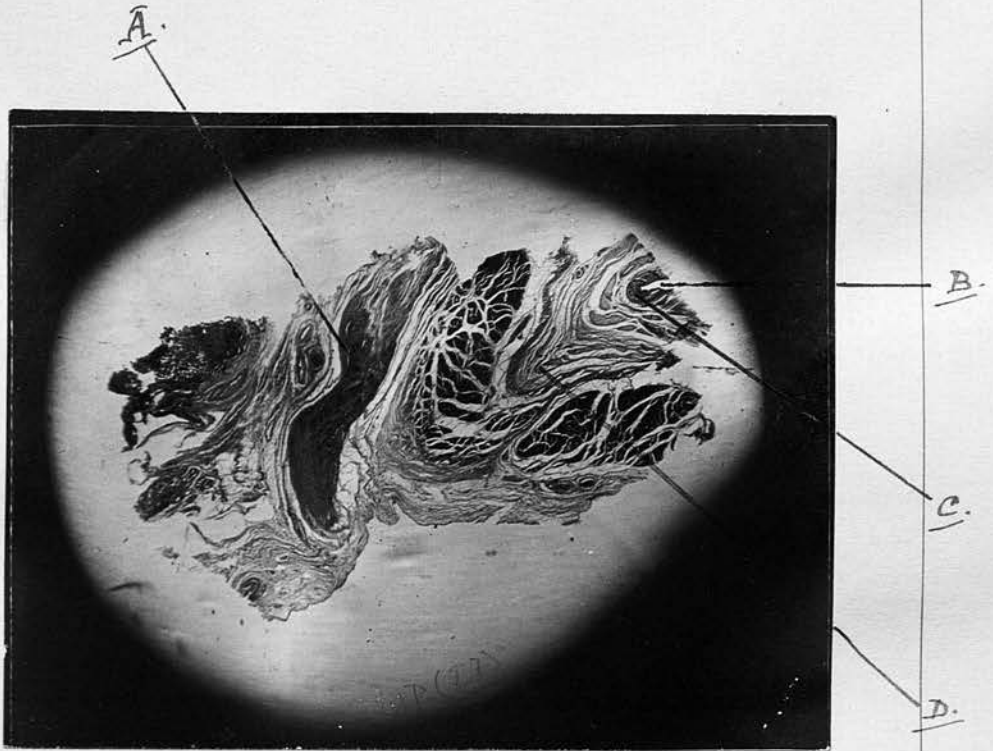
(From Berry Hart's "Descent of the testis").

a disappearance of the proper muscular tissue; and finally a deposition of the fatty tissue around the top of the gubernaculum.

In regard to this last item a fallacy requires to be guarded against; the fallacy is, that at this time in certain parts of the body there is a natural tendency towards the deposition of fat - the groin is one of these parts. We think, however, that the change is too localized to have any meaning other than we have mentioned.

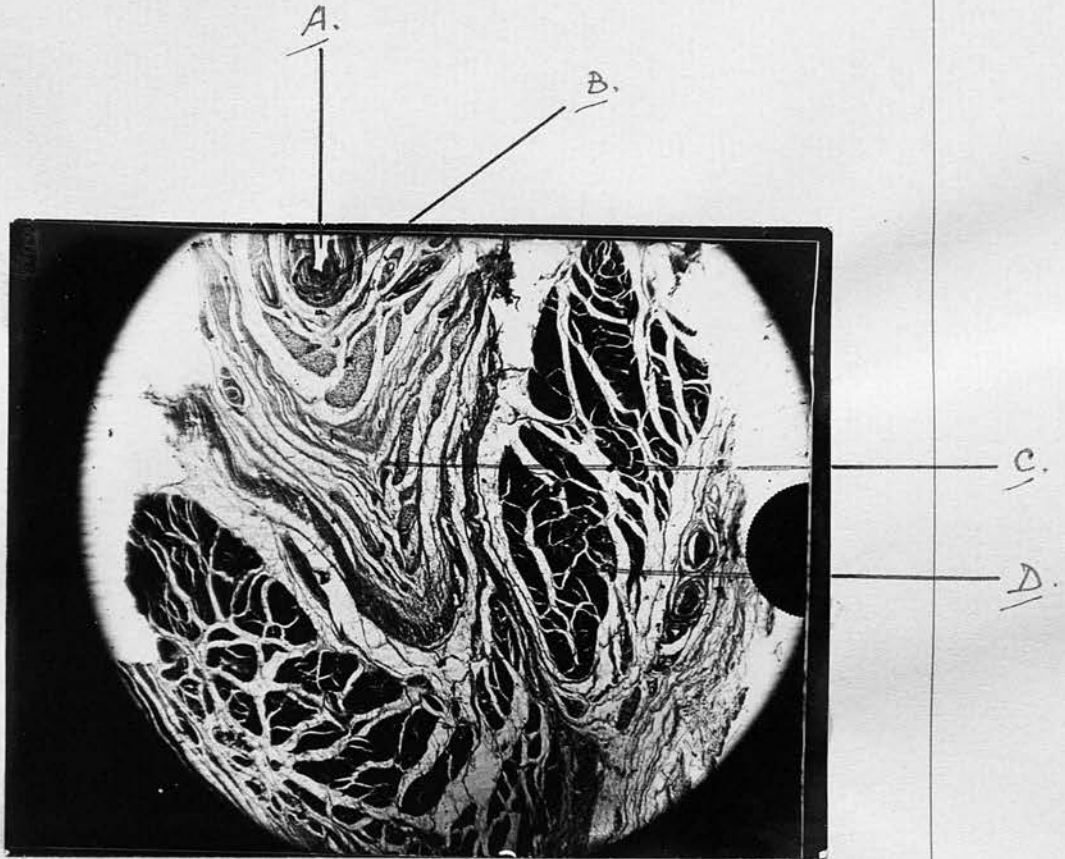
The processus is just beginning to invaginate, and we have been fortunate enough to obtain sections showing this early invagination.

It lies in front of the gubernaculum and appears in the section as a small pouch lined by cubical epithelium which corresponds exactly to that of the parietal peritoneum. There is surrounding the invagination a tissue composed of loose short fibrils and a quantity of cells of all shapes and sizes, many of them fibroblastic in type. Around the end of the advancing processus there is a tissue change similar to that which we noted in the case of the gubernaculum, namely a fatty degeneration and infiltration of the tissues/



Section through Abdominal Wall. The Cone shaped
Gubernaculum is passing downwards among the muscles.
The Processus, as yet separate, is invaginating itself
downwards towards the Gubernaculum.

- A. Gubernaculum.
- B. Processus.
- C. Fibro-Cellular tissue lining Processus.
- D. Tissue atrophy and separation preceding the
advancing Processus!



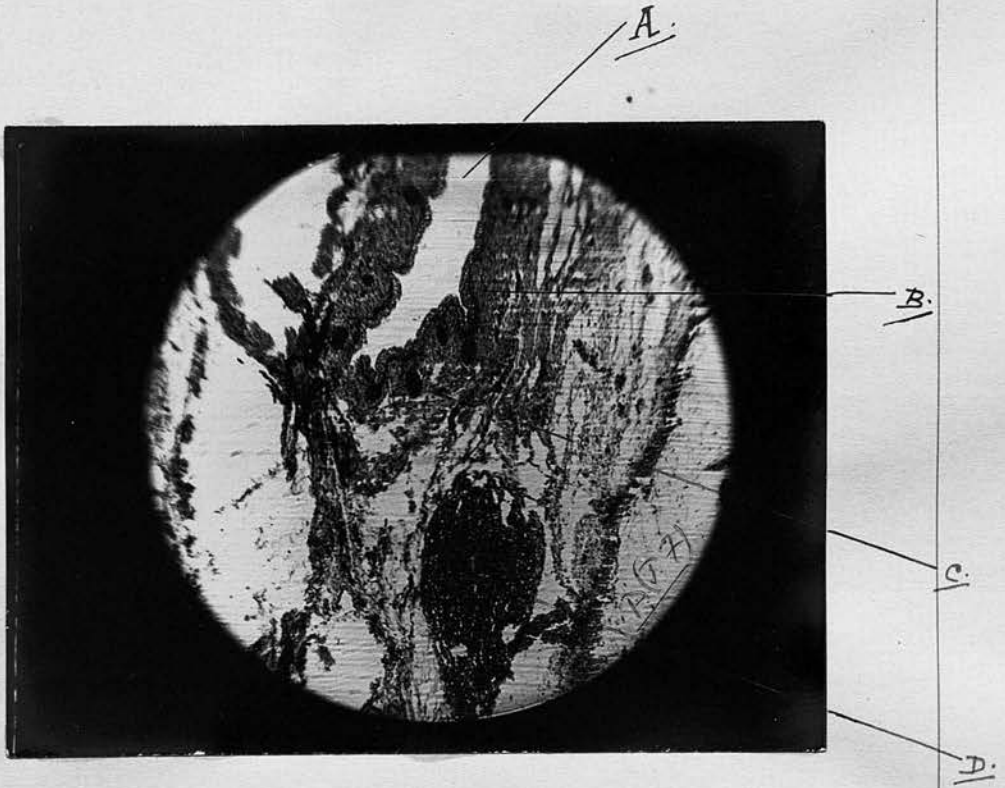
Photograph through the top of the advancing
processus. Note the Atrophy, fatty change and tissue
displacement which precedes the advancing ^{Processus} Gubernaculum. X

- A. Lumen of Processus.
- B. Fibro-Cellular cap.
- C. Tissue Displacement.
- D. Muscular fibres.

tissues with a distinct thickening of the ^{coats:} ~~each~~ of the blood vessels.

There is a special feature to which we attach great importance; it will be seen that in this section the processus has no intimate relation to the gubernaculum, as in later sections it will be noticed to possess. It is entirely free from the gubernaculum, but around its advancing pouch there is a distinct layer of fibro-cellular tissue which entirely coats the advancing pouch. This layer of tissue plays an extraordinarily important part in the advancement of the processus, for at this stage it is by means of this fibro-cellular tissue that the processus develops. It resembles the gubernaculum almost exactly in structure and its function is similar. - a burrowing action through the abdominal wall to make way for the processus which follows exactly in its tracks. The action of this layer of tissue only exists until it has brought the processus into contact with the True Gubernaculum, the tissue then merges with the gubernaculum and becomes indistinguishable from it. As a special factor its action is no longer necessary, it has brought the processus into contact with the gubernaculum and the further advancement of the processus depends upon the latter.

As/



Section of lower end of advancing Processus.

Note the thick cap of fibro cellular tissue which covers it, and by means of which it advances. - Note also the Blood Vessels undergoing a process of obliteration.

- A. Processus.
- B. Fibro-Cellular lining.
- C. Vessel obliteration.
- D. Lymph Node.

As far as we can gather this point has never before been drawn attention to. Its importance cannot be underestimated as it explains the first formation of the peritoneal dimple known as the processus vaginalis.

This section shows the advancement of the processus vaginalis with the surrounding fatty degeneration and vessel thickening. Note specially the layer of fibromuscular tissue which surrounds and envelopes the advancing processus.

How does the fibro-cellular tissue which surrounds the processus work its way into the tissue? The invasion is produced by a system of "budding". We can imagine the first formation of the processus as a tiny peritoneal dimple surrounded by fibro cellular tissue to which we have drawn attention. It surrounds the processus like the fingers of a glove - so close and thorough is its approximation to it.

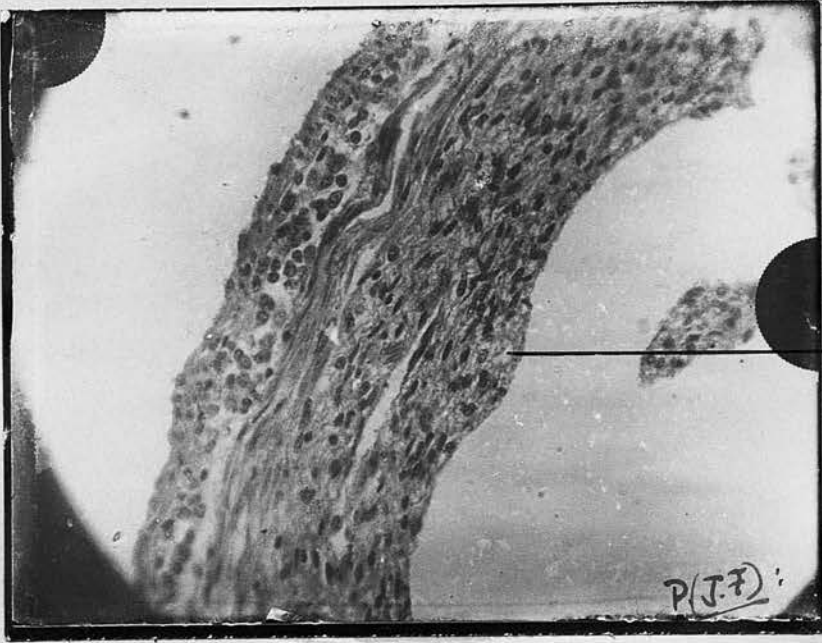
As the time for further descent approaches, there is increased cell activity at certain points along the convex border of the fibro cellular tissue surrounding the processus vaginalis: what we shall call for convenience sake the vaginal gubernatrix. The localized cell activity results in the production at certain points of small finger-like outshoots which seem to extend like so many tenacula from the parent body. These tenacula necessarily invade the tissues where they firmly implant and embed themselves. The production of each series of buds is followed by a further progression in the descent of the processus.

The/

The action is very like that exhibited by an amoeba which by the formation of the pseudo podium alters its position when occasion requires.

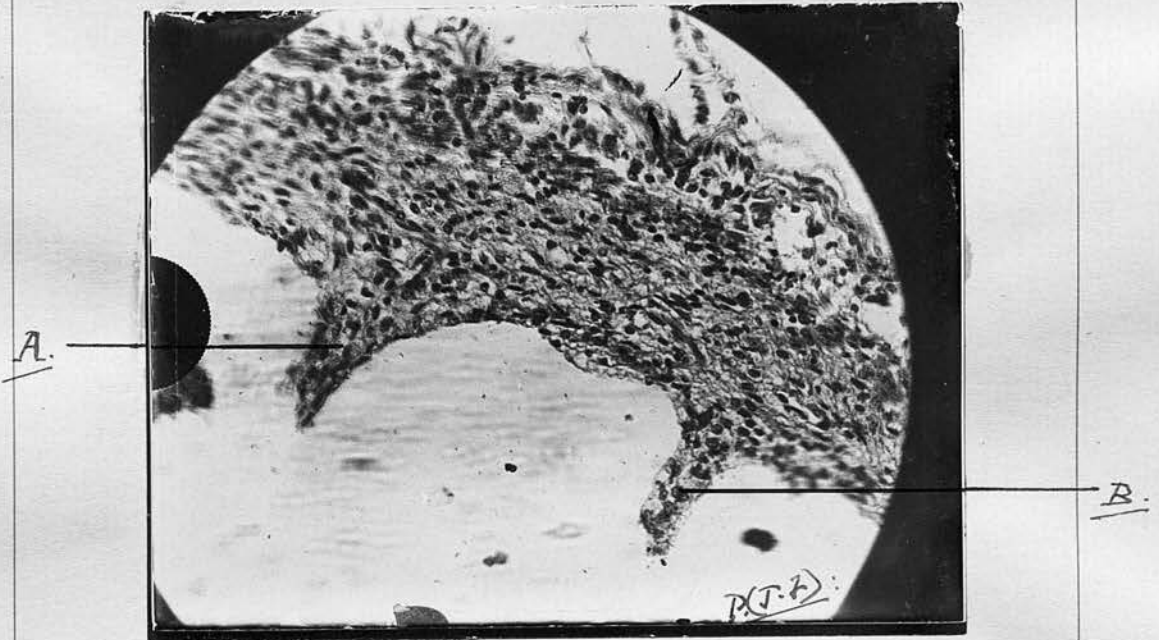
To summarise : - the later part of the 3rd month is fraught with transitions of immense importance.

- A. There is the descent of the gubernaculum and its entire replacement of the plica.
- B. The invasion of the muscular strata of the abdominal wall by the advancing gubernaculum; the method of its advance and the tissue changes which ^{arise} provide it; muscular atrophy; vessel thickening and the deposition of fatty tissue.
- C. The earliest formation of the processus vaginalis, the fact of its being at this stage an item quite distinct from the gubernaculum; the method of its invagination-by means of the fibro cellular lining which it possesses;
- D. The manner of "budding" by which the vaginal gubernatrix burrows into the tissue, drawing the reflection after it.



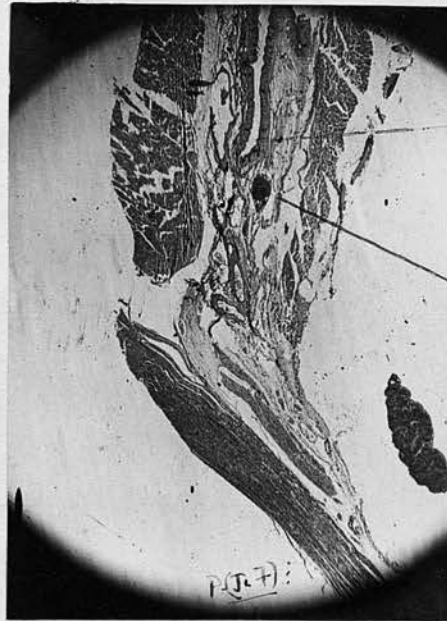
This and the succeeding Photograph shews the method by which we believe the Fibro-Cellular tissue covering the Processus, works its way downwards among the tissues.

At one point "A" one may notice a slight tissue proliferation.



Photograph taken at a later stage. The tissue
proliferation at A has now formed an actual projection
of tissue. A second projection is in process of
formation at B.

The peritoneal pouch or processus vaginalis requires some further description. We have shown it to be a tiny invagination or dimpling of the peritoneum, and we have shown how that dimpling is dependent upon the active fibro cellular tissues which exist like a



Processus Vaginalis

Lymph node

cap around the advancing peritoneum. Also we have shown the tissue changes which precede the advent of the advancing process of peritoneum.

In this early stage of its development, the processus is a U-shaped depression, and between its surfaces there is a distinct space. We shall show how this ~~true~~ space becomes later a purely potential one; at present its lumen is held apart by the budding out of the actively growing tissue in its walls.

We have entered into detail regarding the actual formation of the processus; in its structure there is a further point to which we would draw attention.

When we examine the processus we find that in the/

the substance of the fibro cellular capsule there are numerous blood vessels, or more properly called blood spaces; they are most numerous along the top of the processus where the active growth is occurring. They are



most commonly seen in the early formation of the processus, and towards the termination of the 3rd month they tend to disappear. The method of their disappearance is interesting. The vessel undergoes an actual obliteration; the endothelium which lines the lumen rapidly proliferates and in a short time the once patent blood channel becomes a solid column of cells - at a further stage all traces of their existence are lost.

The significance of this occurrence is as follows, the actively growing tissue, in which they lie, requires for its development a large and continuous supply of blood, and this the blood channels supply. Such is the reason why the blood vessels occur most plentifully around the advancing point of the processus.

How/



Section through lower end of the Processus Vaginalis. The fibro-cellular cap of tissue is well shewn. At the tip of the processus are seen the blood vessels rapidly undergoing an endarteritic or obliterative change.

How is one to explain the later obliteration of the blood vessels? The explanation of the change can be better understood when we explain the changes of the following month.

Briefly it means, that the necessity for a large blood supply is gone, the processus is no longer an actively growing tissue, its further progress will depend upon some other structure (the gubernaculum). Nature therefore, numerous blood vessels being unnecessary, brings about their occlusion.

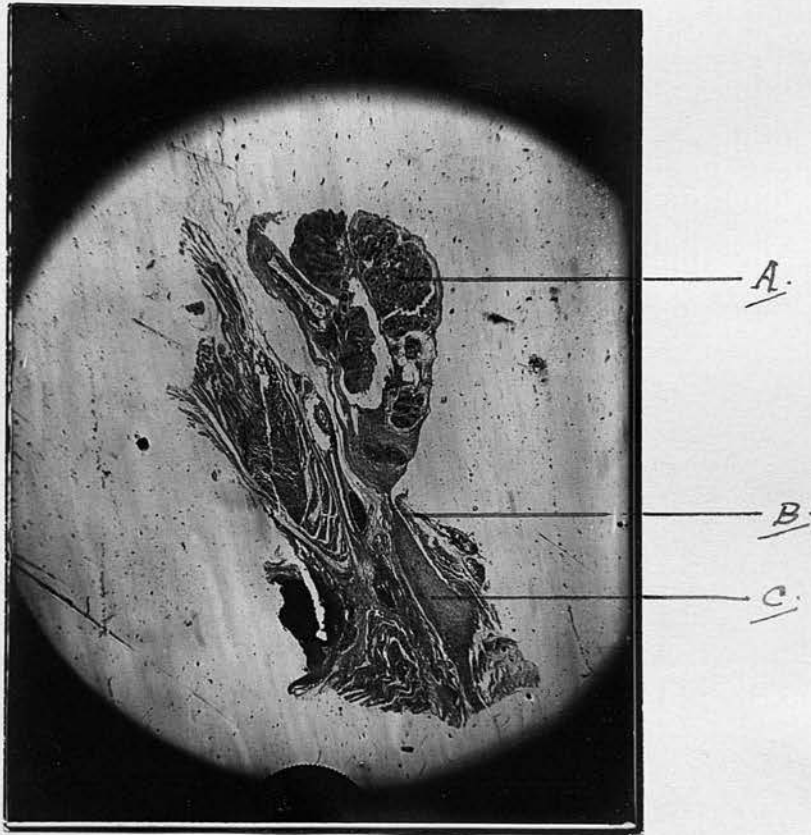
4th Month.

At the end of the 3rd month we had demonstrated the increasing advance of the gubernaculum and the early formation of the peritoneal depression, which goes by the name of the processus vaginalis.

The examination of the 4 months' specimen was carried out by a series of sections passing in the vertical plane of the testis. The sections were paraffin ones - some were stained with haematoxylin and Eosin, others with Van Gieson's stain.

The lower pole of the epididymis comes into view, and descending from it, there is a well marked gubernaculum, the microscopical characters of which we need not repeat.

As/



Section in long axis of testis: Epididymis,
Gubernaculum and Processus. The Processus has now be-
come adherent to the Gubernaculum and is passing down-
wards "parri passu" with it.

- A. Lower end of Epididymis.
- B. Processus Vaginalis.
- C. Gubernaculum.

As we trace the gubernaculum downwards we find it gradually narrowing at a point which corresponds to the later internal abdominal ring.

Beyond this point it gradually thickens and remains thick until it loses itself by breaking into numerous tiny bundles which pass in all directions through the surrounding tissues.

The constriction we merely mention; we can offer no suggestion as to its presence. It was certainly a constant feature in all the sections we had an opportunity of examining.

Extending along the anterior surface of the gubernaculum is the structure upon which the interest of this section depends. Here we have a lateral view of the processus vaginalis, it extends as a narrow slit-like opening along the anterior surface of the gubernacular tissue. Its cavity is quite a potential one, as its walls are normally in contact. It is densely and closely incorporated with the gubernaculum; lining it there is a complete layer of endothelium generally flattened but occasionally cubical in type. Posteriorly this epithelial lining is adherent apparently to the gubernacular tissue, at the most being only separate from it by a thin basement membrane. Anteriorly the invagination is lined by a thin/

thin fibro cellular tissue which bears a distinct resemblance to the tissue of the gubernaculum. But some one will say, "How can you reconcile this state of affairs with what was noticed in the former section, when gubernaculum and processus were distinct structures? How can you account for the fact that they have now become intimately and closely united?"

The explanation is obvious; the processus seen in the former section was actively growing, and this growth was being induced by the fibro cellular tissue which surrounded the invagination. The onward movement of the processus brings it in contact with the anterior surface of the gubernaculum; like tissue is brought into touch with like and an immediate fusion occurs.

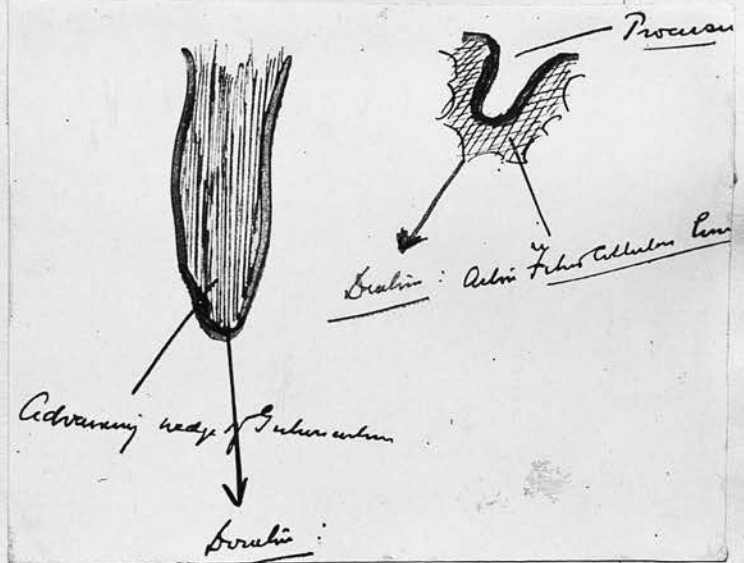
The broad band of fibro cellular tissue which formerly existed around the processus becomes intimately blended with and, in fact, quite indistinguishable from the true gubernacular tissue.

It is now obvious that as the gubernaculum descends it must drag down with it the invaginated peritoneum which has become adherent to it. We believe that the processus as such has no further active descent. Its further movements are purely passive and proceed "parri passu" with the descent of the/
the/

the gubernaculum.

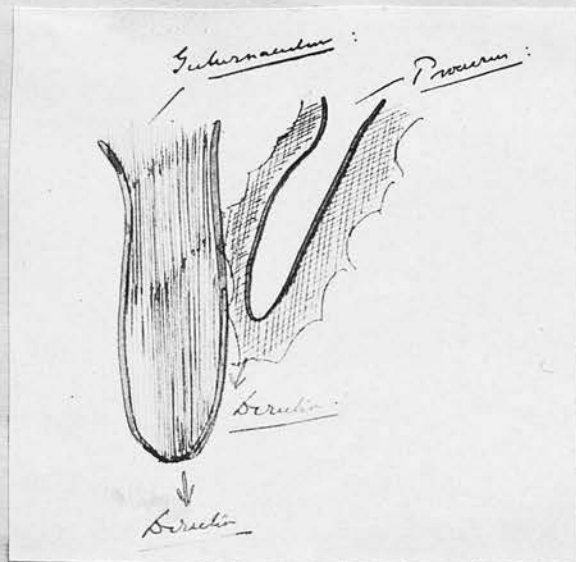
The following rough diagram will explain, better than any words can, the changes which occur; gubernaculum and processus are shown as two distinct entities. The

Gubernaculum is working its way directly downwards. The processus, by the method we have described, is also working its way downwards and backwards and its direction



ion is such that it must inevitably sooner or later come into contact with the gubernacular tissue. The fibro cellular tissue to which the processus owes its formation is represented in the diagram as a thick cap of tissue.

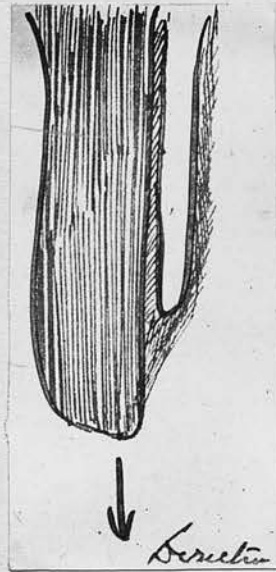
In the second diagram, we have depicted the stage when processus and gubernaculum are just coming into contact. The burrowing action of the gubernaculum



gubernaculum has brought the processes into actual contact with the anterior wall, and cohesion between the two structures has begun.

The cohesion continues and extends along the whole length of the gubernaculum, and in the next diagram we have shown the attachment as complete.

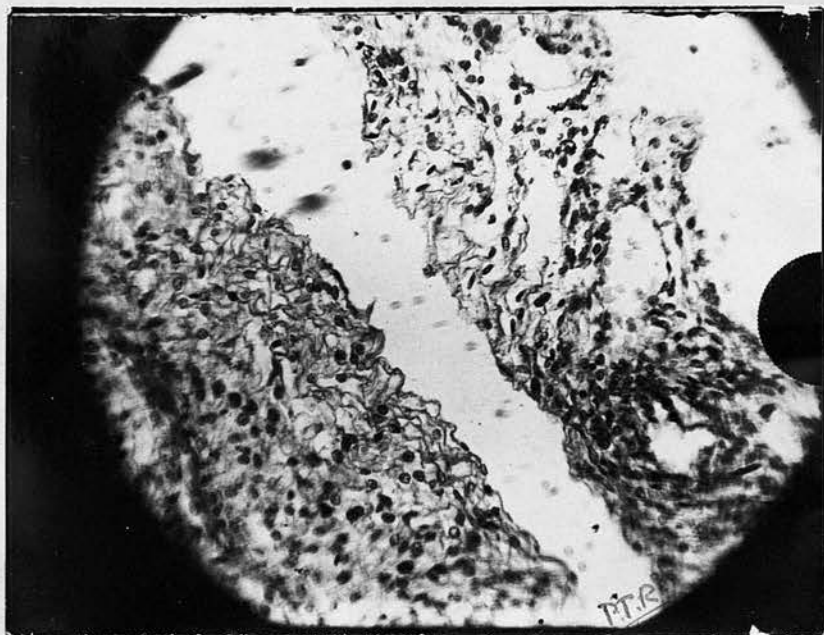
The processus is now an intimate part of the gubernaculum, and its further descent depends upon the



action of the latter structure. The direction of its extent is now continuous with that of the gubernaculum.

By means of these diagrams, therefore, we have shown the mode by which the processus begins its descent, how it becomes adherent to the gubernaculum, and how its further descent depends upon the onward progress of that organ.

The relation which the processus vaginalis thus gets/



Section through Processus vaginalis as it lies
adherent to the anterior aspect of the Gubernaculum. -
Note that there is practically no differentiation be-
tween Processus tissue and Gubernacular tissue.

gets to the gubernaculum is permanently maintained during the further progress of the gubernaculum.

The fibro cellular tissue, which we saw surrounded the processus, cannot now be properly differentiated. It has amalgamated and become indistinguishable from the proper gubernacular tissue. Remains of its structure can be seen along the anterior surface of the processus where it has not lost itself among any gubernacular tissue. Posteriorly, of course, it cannot be distinguished from the gubernaculum.

The processus, as here seen, has many features to distinguish it from the pouched processus of an earlier section.

The lining epithelium is different. Where the process exists as a distinct and separate pouch, we saw that its lining epithelium was cubical in type resembling the epithelium which lines the peritoneum.

When processus and gubernaculum have amalgamated, the epithelium changes its type and becomes squamous. It remains as a squamous epithelium during its further development.

In earlier sections of the processus we showed how there were numerous blood vessels in its structure; we also showed how in the further development of the processus those blood vessels tended to disappear by means/

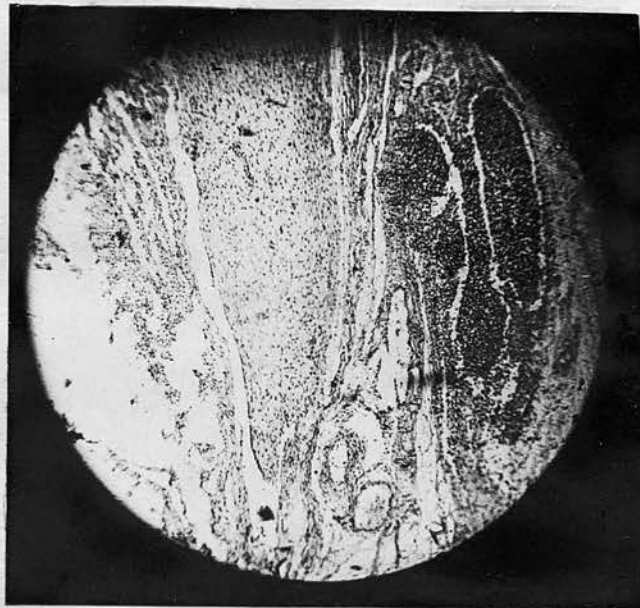
means of an obliterative change.

At this stage they have entirely disappeared, the process is no longer an actively functioning organ, its action now is purely a passive one, its demand for blood supply is small and easily supplied. By nature's inflexible rules of "atrophy"; organs, whose functions are lost, tend to disappear. Therefore the blood vessels, being no longer necessary, vanish.

To summarise the situation.

At the 4th month the processus vaginalis comes into contact with the gubernaculum, becomes adherent to it, and is afterwards pulled downwards by it like a log upon a sleigh.

The gubernaculum is steadily advancing through the tissue of the abdominal wall, and at this date is appearing in the region of the external ring as a bundle of fine white fibres.



The accompanying photograph shows the wedge-shaped appearance of the/

the advancing gubernaculum. Lying close to the advancing wedge there is one of the large lymph nodes, structures which seem to have a curious attractive influence upon the descent of both the gubernaculum and the processus vaginalis.

The descent of the gubernaculum results in the development of the inguinal canal, and in this development it is aided by the cremaster muscle.

The cremaster is derived from the internal oblique muscle and probably in some degree from the transversalis muscle. Together with the gubernaculum and the processus it burrows downwards through the abdominal wall. How far it accompanies the descent of the gubernaculum it is difficult to say, and though it certainly plays a part in the development of the inguinal canal, it cannot be said to take any share in the descent of the testis.

In Rodents there is a modification of the cremaster and gubernaculum in the shape of a structure called the Conus Inguinalis. We mention it because Klaatsch, in the "Morphologisches Jahrbuch", Vol. 16, 1890, describes a conus in the human embryo. He describes it in an embryo 17 c.m. long - he says "Der Conus Inguinalis wird von innen her sichtbar". P. 643. It passed upwards, projecting into the inguinal fold as a rounded cone of tissue derived from fibres of the internal/

internal oblique and transversalis muscles. What function the conus inguinalis plays in the human embryo it is difficult to see. In rodents and insectivora, in which it reaches its highest stage of development, it probably plays some part in assisting the movements of the testis during the rutting period.

5th Month.

The microscopical changes of this month are comparatively few, yet they are of intense interest and form an important link in the chain of evidence which we have been collecting.

Let us first briefly notice the naked eye appearances corresponding to this period. - The Gubernaculum continues to grow in length and breadth, and keeping pace with its descent is the processus vaginalis; the testis occupies a position close to the internal ring; it is usually stated that at this period it rises a little from the ring. Such are the chief naked eye conditions.

Microscopically, the items of interest are mainly to be found in the gubernaculum.

Frankl, "Beiträge zur Lehre von Descensus testicularum," Sitzbericht der K. akademie der Wissenschaften, Wien, 1900, Bd. cix. Hft. i., divides the developing gubernaculum into three portions:-

A/

A. An Abdominal Portion, corresponding to the extent between the testis and the internal abdominal ring.

B. A Vaginal Portion, which is actually situated in the processus vaginalis.

C. An Infravaginal Portion, lying ^{below} ~~between~~ the bulb of the peritoneal dimple.

We described the gubernaculum in the early stages of the descent, (3rd month), and we figured its structure in a microphotograph. At the 4th month we remarked that its structure had somewhat altered. We showed that its structure had become firm and dense, the true fibrillar element had become more distinct, and we hinted that non-striped muscle was visible in its composition. The gubernaculum of the 5th month shows another and most important change - distinct fibrils of striped muscle have appeared, chiefly noticeable in the infravaginal portion. This can be explained by the fact that the striped muscle fibres have probably arisen from the internal and external oblique muscles of the abdomen. The striped fibres are seen as little interval clumps scattered here and there in the gubernacular tissue. What is the inference to be drawn from these facts? We have up to now mentioned three different types of gubernaculum:-

A./

- A. The Earliest type; when the unbroken abdominal wall begins to be infiltrated and invaded, the structure being round celled with a loose fibrillar frame work and, here and there, clumps of myxomatous cells.
- B. The Compact type, seen during the end of the 3rd month, the tissues are denser and firmer than the previous type, the fibrillar framework is more compact, and the myxomatous tissue has largely disappeared.
- C. The Muscular type; as represented by the gubernaculum from the 5th month onwards, when non-striped and, later, striped muscular tissues make their appearance in the gubernacular tissue.

We associated with the gubernaculum two distinct functions:- I. A Burrowing and infiltrating function, by means of which it insinuates itself into and among the tissues of the abdominal wall.

II. A Traction function, which it possesses by virtue of the muscular tissues in its composition.

The tissue, which we have shown to exist in the earliest type of gubernaculum, the active fibro-cellular tissue, is "par excellence" the best type of tissue to perform the early function of the gubernaculum, and therefore it is that, as long as the gubernaculum has an insinuating and burrowing character, (i.e. until the 5th month), so long is its structure of/
cf/

of the description we have shown.

The muscular type of gubernaculum appears at the 5th month and remains characteristic of it until the atrophy and disappearance of the structure. Now, if we, for a moment, hark back to the naked eye character of the period, we shall find that by dissection we showed that this period, -5th month, - corresponds to the time when the gubernacular tissue forms its first true attachment to the symphysis pubis. Further we showed that during the 6th month the testis began to descend.

We associate the descent of the testis with the appearance of the muscular type of gubernaculum. The hitherto burrowing structure has found the fixed point it has been seeking and henceforward it becomes a contracting structure.

Microscopical Characters.6 : 7 : 8 : 9 Months.

Microscopical examination during the later four months of foetal life does not afford us much information and we shall not discuss its features.

The naked eye appearances are all that are necessary in the explanation of the testicular descent.

CONCLUSIONS AND CRITICISMS.

There are few criticisms to be offered regarding the changes which occur during the 1st and 2nd months. We have fully discussed the progress of the development.

The origin of the Wolffian duct was a problem which gave rise to considerable discussion.

His and Henson were of opinion that the Wolffian duct commenced as a longitudinal involution of the epiblast. Fleming considered that the Wolffian duct originated in thickenings of the epiblast. It has now been shown to actually arise in the outer portion of the intermediate cell mass. Kollman, however, has shown that its epithelial lining is derived from the overlying epiblast.

The origin of the testis from the genital ridge requires no comment.

Though Rathke & Arnold describe the testis as developed from prolongations of the tubules of the Wolffian bodies which are transformed into the seminal tubules.

1. Abhandlungen zur Bildungs und Entwicklungs Geschichte des Menschen und der Thiere von Dr Henrich Rathke. 1832.

11. Arnold's Anatomie Des Menschen. Vol. II
p. 1330.

Here an important point crops up. Is it possible at an early stage of development to differentiate the later sex ?

Lockwood in his Lectures upon the Development and Transition of the Testicles Normal and Abnormal; London, 1887. says:-

"It is a matter of common acceptance that at their commencement, no one can discriminate between the rudiments of the ovary and those of the testicles.
. . . . But although at last these glands differ so widely, yet at first they originate from a cell mass which is identical for male and female and which in its early stages betrays no evidence of its ultimate fate whether destined to become an ovary or testicle."

In view of this quotation the following taken from Cleland's work upon the gubernaculum may be of interest:- "As the kidneys grow they appear above and internal to the Wolffian bodies, and the latter come to occupy an oblique position as though separate from them. - If the specimen is a female this declination is continued until they are nearly in a transverse position.

The/

The reproductive organs are at first of an elongated shape. If they are ovaries they retain that shape and exhibit a deep groove along the external aspect where they are connected by the peritoneum to the Wolffian bodies. If, on the other hand, they are testicles, they assume a rounded form and become solid and the contained blastoderm commences to arrange itself in transverse bands."

The advance of the 3rd month introduces us to that period upon the relation of which we can claim to have thrown some light. The features upon which we laid special stress were:-

- A. The commencement of the gubernaculum as an active fibro cellular change at the lower pole of the epididymis.
- B. The invasion of the abdominal wall by the advancing gubernaculum.
- C. The formation of a separate pouch of peritoneum, the fore-runner of the processus vaginalis.

The first statement requires little discussion in its support. It is not a matter for argument, it is a fact which the microscope verifies.

Various authors seem to have different ideas of the situation in which the developing gubernaculum begins.

Odiorne/

Odiarne and Summers in the Annals of Surgery,
 1908. Page 965, make the following statement:-
 "The gubernaculum is derived from a fold of peritoneum covering the Wolffian body and extends in early embryonic life from the lower part of the primitive kidney to the inguinal region (Inguinal fold) (Author) - the testicle is developed from the genital fold, lying between Wolffian body and middle line. As it develops the Wolffian body shrinks, part of it however forming the epididymis and vas deferens - the gubernaculum transfers its upper attachment to the lower portion of the testicle."

Bramann, writing in 1884, says :-
Bramann, "Beiträge zur Lehre von Descensus testiculorum und dem Gubernaculum Hunter's des Menschen," Arch. für Anat., 1884.

"From the point where the vas deferens issues from the epididymis, or, at the junction of the globus minor and vas, the gubernaculum, 1 mm. long and .5 mm. broad, passed to the internal ring."

We have therefore two distinctly different opinions as to the exact situation in which the gubernaculum begins to develop. We have proved to our entire satisfaction that the latter statement is correct.

We/

We have pointed out the method by which the gubernaculum actually begins its development. It is important to note the active proliferation of a fibro-cellular element at the lower pole of the epididymis, which, to the naked eye, produces an actual knot-like thickening.

Cleland gives a curious description of his observations upon the early appearance of the gubernaculum. It is briefly as follows:-

"At the time when the atrophy of the Wolffian bodies has begun, there may be seen very distinctly in the calf and in the rabbit and also in the human subject, though the atrophy occurs at an earlier period, a peritoneal elevation passing from the lower end of the testicle, on the surface of the Wolffian body, to the junction of the epididymis and vas deferens, it shortens and disappears by the approach of these points to one another, and the adhesion of the inferior extremity of the testicle to the end of the epididymis. A more marked elevation continues the preceding one from the latter point to the groin and a pit soon begins to form round the inguinal attachment."

B. The Invasion of the Abdominal Wall by the advancing Gubernaculum.

According to our observations we noticed the commencing invasion of the abdominal wall at the 3rd month; previous to this time, the situation of the gubernaculum being occupied by the inguinal fold, extending from the lower end of the caudal ligament of the testis to the internal abdominal ring.

Frankl and Eberth would appear to have noticed an earlier gubernacular invasion; and as early as the 5th to 6th week they have recorded that the gubernaculum had begun to penetrate and a distinct peritoneal dimple had formed.

Eberth, Die Männlichen Geschlechtsorgane, Fischer, Jena, 1904.

There are few criticisms to be offered. The abdominal wall is invaded by a wedge of the gubernacular tissue. In this way the displacement of the muscular fibres is better accomplished.

We have not been able to verify the fact that, at such an early period as this, striped muscular fibres enter the gubernaculum from the internal oblique and transversalis muscles.

Frankl divides the developing gubernaculum into three portions - abdominal, vaginal and infravaginal, and/

and says that as early as the 3rd month striated muscle fibres radiate into the last named.

Berry Hart, in his work upon the Macropus Ruficollis, lays stress upon the striped muscle fibres, believing that they have a definite part in the invasion of the abdominal wall.

We cannot for a moment agree with these views. During the 3rd month the gubernaculum is an active cellular structure burrowing its way downwards and making a way for itself and its accompaniments through the abdominal wall.

As a fibro cellular production its structure is peculiarly adapted for this function and even its wedge-like shape is specially provided^{for} such.

Striated muscle is for the purpose of producing contraction. At this stage the gubernaculum requires no such function. Is it probable that a structure, which requires to battle for every step it gains, is likely to burden itself with an unnecessary tissue ?

The advancing gubernaculum of the 3rd month possesses no striated muscle in its composition. The reason of the introduction of the muscle fibre we shall discuss later.

We/

We are aware that Berry Hart denies the gubernaculum any traction influence. He says:-

"Gubernaculum testis. - This is John Hunter's term, and is a valuable one. In using this term gubernaculum testis, or "rudder" of the testis, Hunter evidently did not mean to attach more than a "guiding influence" to it. It is often held to involve the idea of traction, but this is unfortunate."

Nature & Physiological Descent of the testis, p. 253.

How is one to reconcile with the above the following statement taken from Annals of Surgery, 1908, p. 963? :-

Odiorne & Summers.

Undescended testis based upon a study of 77 cases.

"There are 3 forms of Ectopia testis.

1. That in which the testis occupies a position in some part of the perineum.
2. That in which the testis is situated in Scarpa's triangle.
3. That in which it is placed near the root of the penis or subcutaneously above the inguinal canal.

These positions correspond to the attachments of certain fibres of the gubernaculum testis which fibres are undoubtedly instrumental in bringing about the malposition."

If/

If the gubernaculum possesses only a rudder influence, why does it ever form fixed attachments; and if it has no traction power, why should abnormal attachments of the testis give rise to corresponding forms of ectopia testis?

Why does the testis delay its descent until the 6th month of foetal life, and why does ~~titer~~ descent immediately follow fixation of the gubernaculum to the symphysis pubis?

These are some of the questions which are difficult to answer, unless we suppose that the gubernaculum at its full development possesses the power of contraction.

The 7th month requires little comment. We observed the appearance in the testis suggestive of pressure having been locally applied; we attributed the fact to the contraction of the abdominal muscles.

The 8th month is occupied with involution of the gubernaculum and increased growth of the processus vaginalis.

The 9th month is occupied with the progressive obliteration of the processus vaginalis.

The Formation of a Pouch of Peritoneum; the Fore-
Runner of the Processus Vaginalis.

Here we feel that we are treading in kingdoms new. The method by which the gubernaculum invades the abdominal wall is an easy problem, but we confess that no text book description ever made sufficiently clear to our minds, the method by which the early dimple of peritoneum was formed. One read of the inguinal wedge beginning to penetrate and the peritoneal dimple being formed. It seemed impossible to believe that the gubernaculum by its early invasion pulled down a small localized pouch of peritoneum, which later became the processus vaginalis. We were satisfied that the processus in its early stage had at least a development as active as that of the gubernaculum, and we consider that in the preceding pages we have built up a strong case in favour of this view.

We are interested to find that Cleland noted the curious structure of the early processus vaginalis. In page 19 of the work upon the gubernaculum he says:-
"The peritoneal projection formed by the processus vaginalis consisted of two layers, the external or cellular and the serous or true membrane."

We would add that this remark was discovered after our own observations had been ~~entirely~~ completed, which latter/

latter were entirely original.

Apart from the undeniable evidence which the microscope has afforded, is it not a most reasonable explanation of a problem, of which up to the present, there has been no adequate solution?

We were taught that the gubernaculum after an active invasion of the abdominal wall pulled down with it a passive process of neighbouring peritoneum. No explanation was suggested why it should pull down a localized portion of the peritoneum, and no conclusions were arrived at how this early "Drag" was produced.

In attempting to gain a sensible explanation of the early formation of the processus vaginalis, some observers introduced remarkable theories.

B. G. Seiler, in an article entitled Observationes Monullae de Testium Descensus, gives the following description:-

"In the region of the abdominal ring a fold or sheath of peritoneum (processus vaginalis) rises up, adhering at the inferior extremity of the testicle with the portion of peritoneum which forms the tunica albuginea. The sheath includes a small conical ligament (Gubernaculum Hunter) formed of dense cellular tissue."

Professor Weber, in 1847, introduced some quite new features/

features to account for the testicular descent. He attributed the main importance to the presence of a short sac which he described as existing within the gubernaculum:-

"The vesicle grows with its upper part into the abdominal cavity and drags asunder the lamellae of the peritoneal folds in which the testis is hung as in a purse, and bears on its muscular fibres which are given off from the internal oblique muscle upwards to near the inferior extremity of the testis.

Hence it is clear that the part called the gubernaculum by Hunter is not a solid cord, but that it is a bladder overlaid by muscular fibres. The under part of the bladder grows downwards from the inguinal canal into the scrotum, drags asunder the cellular tissues and prepares a way for the testis before that organ has left its place.

Thus there exists a large bladder which is narrowest in the middle where it lies in the inguinal canal, whose upper part projects into the abdominal cavity, is broader, and overlaid with muscular fibres, which pass upwards from the internal oblique and cover the bladder in oblique and transverse directions; while the under part of the bladder which is wider, is not overlaid with muscle and descends into the scrotum.

The/

The descent of the testis is effected thus - the upper part of the bladder with the adhering peritoneum is shoved into the lower part, which passes down into the scrotum, just as you can shove the one half of a night cap into the other."

From:- Uber den Descensus Testiculorum bei den Menschen und einige Säugethiere. 1847.

Surely the explanation we have given is more suitable than any of those we have quoted.

And again our theories are entirely founded upon the result of close microscopical observation.

At the 4th month we showed that the processus vaginalis had come into actual contact with the gubernaculum and that thereafter it played a passive part, descending "parri pasu" with the descending gubernaculum. We drew attention to the cohesion which occurred between this pouch of peritoneum and the gubernaculum and how the processus could not descend until the cohesion had been completed.

The structure of the gubernaculum had somewhat altered. It was firmer, denser and more closely knit together; non-striped muscular fibres were present in its composition.

The position of the testis remaining meantime constant/

constant near the orifice of the ^{external} ~~interior~~ ring -

-many authorities note that about this time the testis ascends somewhat from the ring, a feature which is probably due to an increase in length and thickness of the developing gubernaculum.—

At the 5th month we showed that the gubernaculum now possessed distinct striated muscle, and we associated the change with the fact that at this time the gubernaculum formed its first fixed point of attachment to the symphysis pubis.

The presence of striated muscle in the gubernaculum has long been noticed.

Hunter, in an article "upon the Position of the testicle in the foetus and its descent into the Scrotum", writes as follows:-

The History of the Gubernaculum.

"In the foetus the testis is connected in a very peculiar manner with the parietes of the abdomen, at that place where in adult bodies the spermatic vessels pass out. This connection is by means of a substance which runs down from the lower end of the testis to the scrotum, and which at present I shall call the ligament or gubernacular testis, because it connects the testis with the/

the scrotum and directs its course in its descent. It is of a pyramidal form, its large bulbous end is upwards and its lower end is lost in the cellular tissue of the scrotum."

Hunter paid little attention to the process of peritoneum in front of the gubernaculum. He believed the gubernaculum to be fibrous in character and possessing contractile properties.

Girardi, of Parma was the first to describe a number of muscular fibres ascending to the testis. Later Palitta observed them. He considered the question whether they played any part in the descent of the testis, but came to the conclusion that they did not. Panema, - Vienna, 1778, ascribed great importance to the fibres, and considered that, among the causes drawing down the testis while it lies high up in the abdomen, the muscular fibres merited the first consideration.

Panema ascribed some importance to the cellular tissue of the scrotum and thought that since it was capable of corrugating the scrotum, it might also be capable of pulling down the testis.

Ten years later Bengnoni imputed the descent of the/

the testis to the agency of their muscular fibres.

Bengnoni. De Testium Foete Positum Memoires
de l'academie de Scianges de Turm, 1788.

B. G. Seiler. Observationes Nomallae de Testium
Descensum - 1907, thus describes the muscular fibres:-
"This sheath (the processus vaginalis) includes a
small conical ligament (gubernaculi Hunter) formed of
dense cellular tissue which commences at the apex of
the fold, or sheath, where the inferior extremity of
the testis and epididymis are in contact. It thickens
as it descends, it traverses the abdominal ring, and
divides into two slender branches of which one is
joined to the cellular tissue that covers the
aponeurotic expansion before the abdominal ring; and
the other, still more slender, mixes itself with the
dense cellular tissue towards the symphysis pubis. If
we cautiously raise the envelope of peritoneum we
display muscular fibres, which curve upwards from the
internal oblique and transversalis muscles and cover
the cellular mass and adhere to it, so that the
gubernaculum of Hunter seems to be for the great part
a tendinous production of these muscular fibres, for the
passage of cellular tissue into membranous, serous and
tendinous textures, is almost unobservable."

Curling describes the gubernaculum in two parts:-

A/

A soft central gelatinous part and an external and internal muscular part. He succeeded in tracing muscular tissues along the whole length of the gubernaculum from ring to testis.

Cyclopaedia of Anat. and Phys.

Cloquet,¹

Carus,² and

Arnold³ hold that the origin of the muscular fibres seen is as follows:- They are derived from fibres which extend from Poupart's ligament to the pubis, preceding the testis in its descent in the shape of arches in the surface of the processus vaginalis.

1. Jules Cloquet. Recherches Anatomique sur les Hernis de l'abdomen. 1807.
2. Carus. Comparative Anatomy by Gore.
Vol. II. p. 347.
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It is now commonly recognised that the muscular fibres are the result of an ingrowth from the internal oblique and transversalis muscles of the abdomen.

We associate their appearance with two facts: -

- A. The attachment of the gubernaculum to the symphysis pubis during the 5th month.
- B. The descent of the testis immediately after this has been completed.

We/

We would sum up our view of the method of testicular descent as follows:-

1. An invasion of the abdominal wall by the fibro cellular tissue of the developing gubernaculum.
2. An invasion of the abdominal wall by the developing processus vaginalis, the processus being enabled to invade the walls by a layer of active fibro cellular tissue which surrounds it.

These changes occurring separately at the 3rd month.

During the 4th month the processus vaginalis comes in contact with the descending gubernaculum, adheres to it, and descends with it.

At the 5th month the gubernaculum acquires an attachment to the symphysis pubis and possesses striped muscular tissue in its composition. The gubernaculum is no longer an invading structure, it becomes contractile and the testis responds, being drawn down by the gubernaculum behind the processus vaginalis.

The contracting gubernaculum brings the testicle within the grasp of the abdominal muscles and by these contractors it is expelled along the canal through the external ring. Beyond the external ring the testicle is further helped by its own weight and the movements of the viscera and muscles.

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THE ANATOMY OF INGUINAL HERNIA.

THE NORMAL ANATOMY OF THE INGUINAL REGION.

Before discussing what is really the morbid anatomy of hernia, we shall briefly review the more important points in the actual anatomy of the Inguinal Region.

These are mainly the structures comprised by the Two Rings, External and Internal; the Inguinal Canal; the Spermatic Cord; and the Relations of the Deep Epigastric Artery.

The External Ring is a split in the aponeurosis of the external oblique, where the fibres separate just about the spine of the Pubis. It transmits, in the male, the spermatic cord and, in the female, the round ligament of the uterus. The opening is not entirely patent, the edges are drawn together by an interweaving and binding of strong arched fibres, passing from one pillar of the opening to the other, and constituting the Intercolumnar fascia and fibres. When traced, they are found to arise from Poupart's Ligament, thence passing inwards to sweep across the external ring. The margins of this ring constitute its pillars - the outer, narrow and continuous, with the inner end of Poupart's Ligament, as it passes to the spine of the pubis; the inner, broad and flat, practically a portion of the external oblique aponeurosis/

eurosis, as it descends to be attached to the crest and symphysis of the pubis.

Partly from the pillars of this ring and partly from the above mentioned intercolumnar fibres, there passes downwards upon the cord, as it emerges from the ring, a tubular fascial process, constituting the External spermatic or intercolumnar fascia. This will be mentioned later in dealing with the Coverings of the Hernial Sac.

One more point:- Behind the internal pillar, there is a strong band, called the Triangular Fascia, prolonged really from the external oblique aponeurosis of the one side to be inserted into the crest and spine of the pubis of the opposite side. The fascia is one of the strongest safeguards which this naturally weak region possesses.

The Internal Abdominal Ring is situated half an inch above Poupart's Ligament, midway between the anterior superior spine and the symphysis pubis. Its presence, at this point, is constituted by the spermatic cord piercing the fascia transversalis, the latter being prolonged along the cord as the infundibuliform or internal spermatic fascia. When viewed anteriorly it is difficult to appreciate its characters/

characters as a ring, but when looked at from the posterior aspect, it gives one the impression that one is looking at a finger in the stall of a glove; the cord corresponding to the finger, and the glove corresponding to the tubular prolongation from the fascia transversalis.

Connecting the internal ring with the external, we have the region known as the Inguinal Canal, measuring one and a half inches long and directed downwards and inwards and forwards. Through this canal, the spermatic end of the male and the round ligament of the female pass.

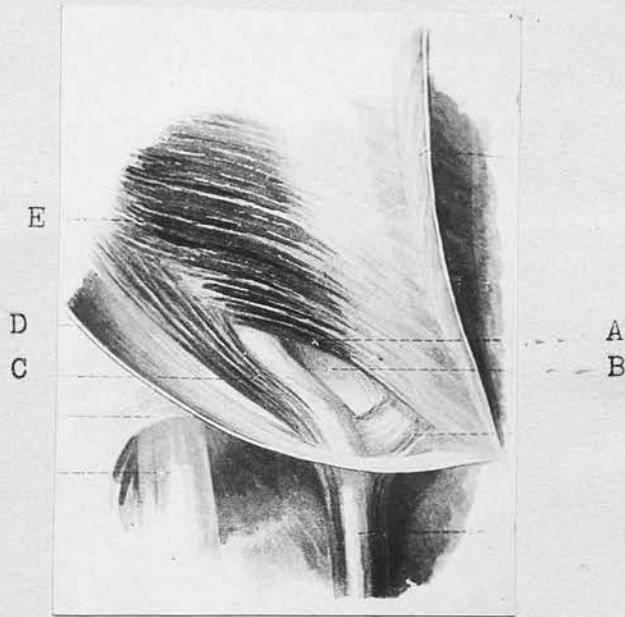
It is usually spoken of as having:-

- A. An Anterior Wall, formed by the aponeurosis of the external oblique and, in its outer part, by the muscular fibres of the internal oblique.
- B. A Posterior Wall, formed by the fascia transversalis and internally by the conjoined tendon.
- C. A Floor, formed by Poupart's ligament and, more internally, by Gimbernat's ligament .

Lastly we would mention The Deep Epigastric Artery, a structure of eminent importance in the operative treatment of Inguinal Hernia. It is a large vessel arising from the external iliac artery immediately above/

above Poupart's ligament. Its course is at first upwards and inwards in the extra peritoneal fat, along the inner side of the internal abdominal ring, forming thus the outer border of Hesselbach's triangle; it then pierces the fascia transversalis, passes over the semilunar fold of Douglas, and enters the sheath of the rectus abdominis. It ascends for a short distance behind the rectus, but it soon penetrates the muscle and breaks up into branches which anastomose with the superior epigastric branches of the internal mammary and lower intercostal arteries. In the male, just at the internal ring, the vas deferens, the spermatic vessels, and the genital branch of the genito-crural nerve hook round the front and outer side of the artery, the vas deferens turning inwards behind it. In the female the round ligament and the genital branch of the genito-crural nerve occupy a corresponding position.

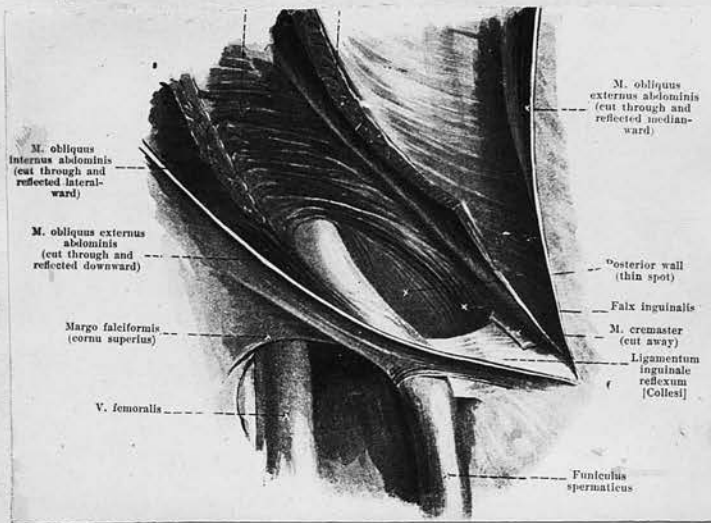
The Composition of the Spermatic cord requires only to be mentioned. It is a composite structure, being made up of many parts - the vas deferens and its vessels, the spermatic artery, the pampiniform plexus, the cremaster muscle, nerves, lymphatics, and connective tissue, which is continuous with that of the sub-peritoneal/



The Inguinal Canal.

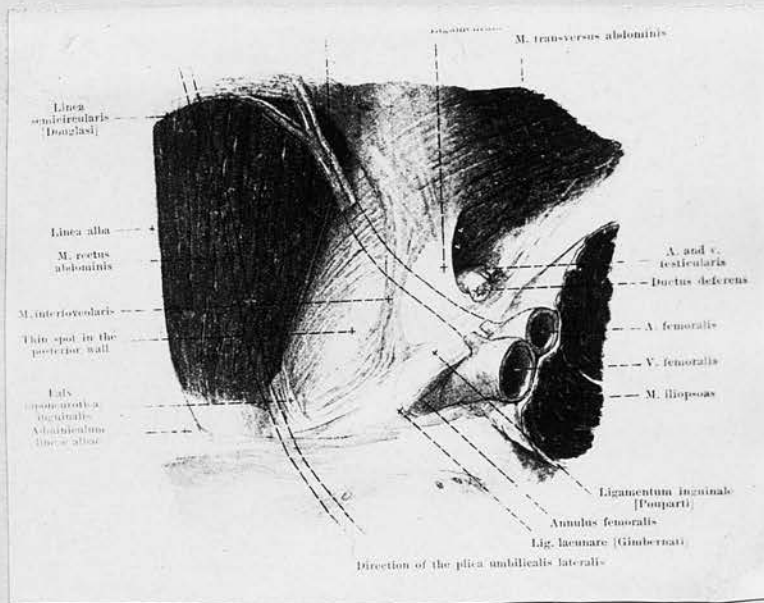
(Atlas of Anatomy - Spalteholz).

- A. Upper wall of Inguinal Canal.
- B. Post wall of Inguinal Canal.
- C. Origin of Cremaster.
- D. Reflected External Oblique.
- E. Internal oblique.



Right Inguinal Canal.

(Atlas of Anatomy - Spalteholz.)



Posterior Wall of Right Inguinal Canal - viewed from behind. (Atlas of Anatomy - Spalteholz.)

peritoneal tissue above and that of the scrotum below. Besides these there may be present the remains of the imperfectly obliterated processus vaginalis.

THE ANATOMY OF INGUINAL HERNIA.

The word Hernia is probably derived from the Greek word "Ernos", meaning "an offshoot", and strictly speaking may be applied to any protrusion or projection from the surrounding surface. When employed alone, the term has come to be used synonymously with the word "Rupture", and is applied to a protrusion of some one or more of the abdominal viscera.

The term Inguinal hernia applies to all hernias having an exit through the inguinal canal. They are subdivided into:-

1. Direct Inguinal hernia, in which the sac enters the canal at its lower end and leaves it by the external ring. This variety is almost always associated with a defective development of the internal oblique.
11. Oblique Inguinal hernia, in which the sac, having entered the canal through the internal ring, traverses the canal completely and finally leaves it/

it through the external ring.

As in the group we are to discuss no case of Direct Inguinal hernia occurs, this class may be left entirely out of account.

In oblique inguinal hernia the sac emerges from the abdomen through the internal ring, to the outer side of, and slightly above, the deep epigastric artery. It then passes obliquely downwards and inwards to cross the deep epigastric vessels, almost at right angles, finally appearing at the external ring. Beyond the external ring it passes, in the male, into the scrotum; in the female, into the labium. According to the degree of its progress, it is called a Bubonocoele, before it has passed through the external ring; a scrotal or labial hernia when it has emerged from the ring.

In the passage of the sac through the canal, it lies upon the peritoneum and transversalis fascia: While above, it is in contact with the internal and external oblique muscles, the aponeurosis of the external oblique^{and} cremaster muscle^s. As the sac descends, it always occupies a definite position as regards the cord; it usually lies directly in front of it, but bound closely to it by the respective coverings, the vessels of the cord being spread out in/

in a fan-like manner upon the posterior aspect, and the vas lying by itself more internally.

These remarks, in the main, apply to female hernias. The sac here, however, is in relation to the round ligament, upon the anterior and outer aspect of which it lies. The sac is a feature common to all hernias, with the exception perhaps of some diaphragmatic types. In oblique inguinal hernia, it is formed by the layer of parietal peritoneum which covers in whole or in part, the contents of the hernia. In the congenital variety of hernia this process of peritoneum is preformed; in the acquired type, it is the result of a gradual progression and stretching of the peritoneum.

The shape of the sac varies enormously; its uniform appearance, however, is pear-shaped, the narrow portion being called the neck of the sac; and the lower dilated portion, the fundus. Some authorities hold that congenital and acquired hernias show different types of sac. Bayer, for example, says:- "In the congenital variety, the sac is pear-shaped with a narrow neck; while in the acquired type it has a broader neck and a narrower base." Clogg, in the Practitioner, 1908, p. 366, says:- "In/

"In many cases, the most superficial examination of the sac will reveal its congenital origin. The sac is often irregular in its interior, sometimes showing almost complete septa, more often constrictions, flaps, or valves. Not infrequently, the sac is somewhat hour-glass in shape, or distinctly lobulated. The sac at the site of the internal ring is often very narrowed, as would be expected if it were of congenital origin. Even when such conditions of the sac are not obvious at a glance, stretching out the sac, and a little more careful examination of its interior, may reveal something of the sort which is sufficient to stamp the sac as one of congenital origin. It sometimes happens that no such peculiarities of the sac are seen."

The neck of the sac has been much discussed as a probable cause of strangulation, but in children this is seldom, if ever, the case; the obstructing cause in such being the cross-branching fibres of the external oblique where it forms the external ring.

When these fibres are snicked, ~~the~~ contents can practically always be reduced.

The classification of the actively different types of sac is varied; that most generally employed is the division into:-

1. Funicular.
11. Vaginal types.

The/

The former term being applied to those sacs in which the Funicular process and tunica vaginalis testis do not communicate; the latter, to the type in which they do.

The general characters of the sac are well known. It is recognised as a thin fan-like projection, bearing always a definite relation to the cord structures among which it lies. Its outer surface is roughened, and adherent to it in parts one finds traces of the infundibuliform and cremasteric fascias; the relation of the former to the sac being very close. The inner surface is smooth and glistening, with all the characteristics of a serous membrane.

The microscopical characters are dealt with more fully later. But to complete the description of the sac we would say that internally it is seen to be lined by a layer of endothelium, cubical or flattened, these cells resting upon a thin homogenous basement membrane. Externally the structure is completed by a fibrous or fibro-cellular structure.

One would imagine that the presence of a hernia sac could be detected by a careful comparison of the relative thickness of the cords of different sides.

"Carmichael, of Edinburgh, examined 86 children, and Corner, at Great Ormond Street, examined 200, when
no/

no recognisable hernia was present, to ascertain the approximate percentage in which the spermatic cords of the two sides were equal and unequal: -

	Carmichael. per cent.	Corner. per cent.
Cords equal	21	30.
" unequal	79	70
Cord of right side the larger	59	65
" " left " " "	41	35.

Thus the figures, agreeing in the main, differ in detail. The two deductions which can certainly be made are:-

- (1) That in about three out of four children the spermatic cords are unequal in size, that of the right side being usually the larger.

In contrast with this, in 85 per cent of 100 adults at St. Thomas's Hospital the spermatic cord of the left side was the larger. The inequality in the spermatic cords of children is due to the imperfect obliteration of the funicular process of the processus vaginalis and the imperfect absorption of its surrounding subperitoneal fat; in adults it is due to the physiological formation of a greater number of spermatic veins on the left side than on the right - what might be called a mild form of natural varicocele.

(2)/

- (2) That in children the right spermatic cord is the larger in two thirds of the cases, whilst in adults the left spermatic cord is the larger in nine tenths of the cases." The Journal of Children's Diseases, Feb. 1909.

The Coverings.

The sac, when exposed by dissection, is found to be covered by certain distinct anatomical structures, or "Coverings." They are said to be three in number, and by careful dissection their individuality may be established. Most externally one finds the inter-columnar or external spermatic fascia, derived from the already mentioned cross branching fibres which bind together the pillars of the external ring. The second or cremasteric fascia, constitutes the most marked and distinct covering, and it is applied to the sac as it passes beneath the lower border of the internal oblique. Lastly, as the sac enters the tube or opening in the transversalis, it derives from it the covering known as the infundibuliform fascia.

Certain authors recognise other coverings:- extra peritoneal fat; superficial fascia, and skin; their introduction, however, is unnecessary.

Perhaps it would be well, at this point, to state/

state briefly the views commonly held regarding the method of formation of the hernia sac.

Again and again throughout this article the question will be referred to, and we hope to introduce some features which may aid in the elucidation of the problem. But briefly stated, there are two main theories of hernia formation:-

The first or sacular theory, associated with the name of Russell of Melbourne, infers that herniae appear on account of the sac being formed during development.

The second theory, first introduced by Arbuthnot Lane, in 1897, argues that the majority of herniae in children arise from the increased intra-abdominal pressure of intestinal fermentation.

Corner, American Journal of Medical Sciences, June, 1907, in dealing with the latter view, says:-
"The hernia can be produced in either of two ways, or by a combination of both: first, the intra-abdominal pressure may protrude the hernia by direct pressure; second, and more commonly, the pressure acts indirectly by modifying the growth of the tissues, particularly in the weaker regions, facilitating the development of a hernia by direct pressure later. By the indirect action/

action on its growth, the raised intra-abdominal pressure destroys the protective valvular action of the inguinal region, after which a hernia is formed. In very young children the valvular action may be rendered incompetent by the mere stretching of the soft growing tissues. Thus, the younger the child the shorter the time required for the development of a hernia. But the mere presence of a hernia in a child shortly after birth does not necessarily indicate its congenital origin; for instance, it is known even with the tougher tissues of adults that a hernia may appear in a few hours or days."

Action of the Inguinal Canal.

The inguinal canal has a definite muscular action, the aim of which is to diminish or close the bore of the inguinal canal. Its action is best seen during an operation, when the canal has been exposed and the patient strains or coughs. Sometimes the muscular action is so strong as actually to force out the finger should it be introduced into the canal.

The source of the action is as follows:-
the front and back walls of the canal are forcibly brought together and at the same moment the arciform fibres of the internal oblique and transversalis shorten/

shorten and ^{descend} ~~ascend~~ upon the spermatic cord. The result of this action is that the spermatic cord is forcibly pressed down upon Poupart's ligament, obliterating the space which would otherwise exist in this situation. Poupart's ligament also plays a part in the closure of the canal. At rest, it forms a slight curve with its convexity towards the thigh. When the external oblique contracts, it becomes straighter and more rigid and is thus approximated to the arching fibres of the internal oblique and transversalis.

Such is a brief resume of the present day knowledge of Oblique Inguinal Hernia. The facts we have noted are by no means new, but those we are now about to introduce are the result of original investigation and research.

Some Clinical features gained from a study of
1000 Cases of Oblique Inguinal Hernia occurring in
male children under the age of 12 years.

THE ETIOLOGY OF INGUINAL HERNIA.

THE ETIOLOGY OF INGUINAL HERNIA.

This is a subject around which the war of discussion has hotly raged; and yet perhaps one may say that anything like a proper explanation of many of its factors has yet to be offered.

One may classify the causes as follows:-

A. Predisposing Causes.

B. Direct Causes.

A. Predisposing Causes.

I. Age. The Hospital for Ruptured and Crippled, in a Report issued in 1907, shewed that out of a total of 75.544 cases of Hernia actually admitted to the Hospital

25.126 cases occurred below 14 years of age.

4593 " " between 14 & 21 years.

45.825 " " over 21 years of age.

Our own observations have been carried out upon children under 12 years old, and, in this respect, the following table may be of interest:-

AGE.	Hernias.
To 1 month	1 case
" 2 " s	8 " s
" 3 "	39 "
" 4 "	68 "
" 5 "	85 "
" 6 "	83 "
" 7 "	59 "
" 8 "	70 "
" 9 "	35 "
" 10 "	49 "
" 11 "	40 "
" 12 "	48 "
1 to 2 years	382 " }
2 " 3 "	173 " }
3 " 4 "	77 "
4 " 5 "	60 "
5 " 6 "	58 "
6 " 7 "	44 "
7 " 8 "	24 "
8 " 9 "	19 "
9 " 10 "	28 "
10 " 11 "	13 "
11 " 12 "	4 "

Such a table demonstrates well the enormous preponderance of hernias occurring in the first two years of life. Such a table, however, is open to this objection; that it does not furnish evidence of the total number of cases admitted to hospital. Accordingly we have added a second table which demonstrates, in addition to the above facts, the actual occurrences of hernia, in proportion to the number of cases actually admitted:-

Age.	Total No. of cases.	Hernias.	Percentage.
to 1 month	108	1	91%
2 "	47	8	17%
3 "	121	39	32%
4 "	171	68	39%
5 "	160	85	53%
6 "	156	83	53%
7 "	127	59	46%
8 "	145	70	50%
9 "	88	35	39%
10 "	108	49	45%
11 "	69	40	57%
12 "	97	48:	49%
1 - 2 years	917	382	41%
2 - 3 "	627	173	27%
3 - 4 "	506	77	13%
4 - 5 "	492	60	12%
5 - 6 "	410	58	14%
6 - 7 "	410	44	10.7%
7 - 8 "	314	24	8%
8 - 9 "	263	19	7%
9 - 10 "	239	28	11%
10 - 11 "	205	13	5%
11 - 12 "	75	4	5%
over 12 "	6	-	

This report is of special interest, probably few people realise the enormous part which Inguinal Hernia plays in children's diseases. As the Table shews, in the cases admitted to the Edinburgh Sick Children's Hospital whose ages ranged from 6 months to 1 year, no less than 50% were afflicted with Inguinal Hernia. The period examined extended over nine years and the actual number of cases investigated numbered 5,861. Speaking roughly, 1 case in every 6 was afflicted with Inguinal Hernia.

Professor D. G. Grase says:-

" 1 in 20 to 30 people have rupture.

1 : 14.9 in males.

1 : 44.7 in females.

Greatest number seen during 1st year of life.

Minimum " " " 15th " " " . "

Whilst we are engaged in this subject of herniae in relation to age, we shall give some statistics of further interest.

The first is in regard to the age of the child when the hernia was first seen. The facts have, of course, been wholly obtained from the parents, and the figures are given for what they are worth:-

In regard to Age of Child when Hernia was first seen.

	<u>Total</u> <u>number.</u>	<u>Males.</u>	<u>Females.</u>
<u>Essentially congenital, i.e.</u> <u>seen at birth</u>	112	104	8
<u>Seen during first month</u>	142	138	4
<u>Seen during 2nd month</u>	125	113	12
<u>Seen during 3rd month</u>	74	68	6
<u>Seen during 4th month</u>	21	20	1
<u>Hernia seen from 4th to 6th month</u>	35	33	2
<u>Hernia seen from 6th to 12th month</u>	55	49	6
<u>Hernia seen from 1st to 2nd year</u>	36	24	12
<u>Hernia seen from 2nd to 3rd year</u>	13	7	5
<u>Hernia seen from 3rd to 4th year</u>	11	4	7

A/

A curious fact in this table is the corresponding increase of female herniae as the age of the child increases. Out of a total of 112 cases seen at birth, 8 cases were females; while out of 11 cases seen during the third year, no less than 7 were female cases. It is obvious then, that as age increases the proportion of female herniae correspondingly increases. Following up this fact we have prepared a table which shews the sex of hernia cases when the child was over 5 years of age, before the hernia was noticed: -

	Age when noticed.	Male.	Female.
F x	5 $\frac{1}{2}$ years	-	x
F x	6 years	-	x
F x	6 $\frac{8}{12}$ yrs.	-	x
F x	4 $\frac{8}{12}$ yrs.	-	x
M x	8 $\frac{1}{12}$ yrs.	M	-
M x	6 $\frac{1}{12}$ yrs.	M	-
F x	6 $\frac{1}{2}$ yrs.	-	x
F x	6 yrs.	-	x
F x	7 yrs.	-	x
F x	7 yrs.	-	x
F x	6 yrs.	-	x
M x	8 yrs.	M	-
M x	6 yrs.	M	-
F x	8 $\frac{1}{2}$ yrs.	-	x
M x	6 $\frac{1}{12}$ yrs.	M	-
M x	5 $\frac{4}{12}$ yrs.	M	-
F x	9 $\frac{2}{12}$ yrs.	-	x
F x	5 $\frac{1}{2}$ yrs.	-	x
	4 $\frac{8}{12}$ yrs.	M	-
{ Females 11 }			
{ Males 6. }		14	12

Out of 17 cases over 5 years of age, 11 were females. It is a curious fact. We have failed to find/

find any definite reason for it, and we merely state it as an interesting feature.

II. SEX.

The proportion of male to female inguinal hernias has been variously expressed by different authorities. Again to quote the Report (1907) of the Hospital for Ruptured and Crippled - it gives the proportion of cases as being 75.5% male and 24.3% female.

Beiger, (Extrait du traite de chir. 2nd Edition), gives much the same proportion, namely, 75% males and 25% females.

Macready, (Statistics of the London Truss Society, 1888 - 90), states the proportions as 80% and 20% respectively.

Our own statistics shew results somewhat different from those already stated:-

Total Number of Operations = 1000.

Male Cases = 906.

Female cases = 94.

Percentage = 10.37% of cases are females,
while 89.6% are males.

The percentage of male cases is almost 90%, much higher than any of the above mentioned percentages. The Reports which shew a comparatively high proportion of female cases have been obtained from Continental and American/

American institutions which employ upon their staffs female assistants. This fact may yield the possible explanation.

III. HEREDITY has been mentioned by some as being a predisposing cause of inguinal hernia. Such does not agree with our observations. We have been able to lay hands upon only two cases which shewed a family history of hernia.

Beiger examined 7542 cases and found 2079 positive - i.e. 1 : 3.6.

We shall now discuss the direct causes of inguinal hernia, and such, of course, entails the mode in which the hernia is formed; the latter being a question which has long exercised enquiring minds, and which can hardly yet be said to have arrived at finality.

The earliest opinions upon the subject are shewn by the popular terms used to express the condition. The word "Rupture" implies a bursting forth of the bowel from the abdomen, and the Germans use the word "Bruch" in the same sense. The direct ^{Causes:} ~~causes~~ may be classified as follows:-

1. An increase of intra-abdominal pressure.
2. Congenital malformation of the abdominal wall.
3. The presence of a ~~preformed~~ sac.

1. Increased/

1. Increased Intra-abdominal Pressure.

While the other direct causes of hernia may play very powerful assisting parts, there can be no doubt that an increase of intra-abdominal pressure is the main underlying factor in the causation of hernia. In very many cases there is a definite history of coughing or straining, and we have collected the supposed causes of 200 cases of inguinal hernia. A glance at the list will shew how prominent a part the ^{above} ~~present~~ feature plays. Yet it must be recognised that contributory conditions must be present before a hernia can be formed. These will be discussed in due course. Keen says:- "Anything which increases the intra-abdominal tension may be the immediate exciting cause of a hernia." (Keen's Surgery, Vol.IV, p.26.) Berger examined 4621 cases with reference to the exciting cause. 1427, or 30.9%, attributed the condition to some specific exciting cause. In 438 of these cases, such cause was supposed to be a fall or strained position. (Extrait du traite de Chirurgie, 2nd Ed.)

The Hospital for Ruptured and Crippled has
observed 5282 cases of hernia:-

83 were said to be due to straining,
8 to coughing, and
6 were attributed to falls.

In a more recent observation upon 4780 cases:-

1015 were attributed to attempting to raise a heavy weight,

150 to coughing and sneezing,

123 to straining,

89 to falls,

40 to blows upon abdomen,

8 to kicks.

51 had been noticed since birth.

Moynihan says:- "The most active of the determining causes of inguinal hernia in children are:- Ill-feed-
ing leading to gaseous distention of the intestine and
increased intra-abdominal pressure; others of less
influence are Phimosis with adhesion of the Prepuce to
the glans;; Retention of the secretion of Tyson's
glands; Vesical Calculus; Rectal Polypus; Intestinal
irritation by parasites, or any condition leading to
persistent straining ^{on} of the part of the patient."

After such quotations as these we need not apologize for submitting the following table. It bears out closely the facts displayed in the foregoing statements. In all, 207 cases have been analysed.

Table //

Table to demonstrate the Supposed Causes of
Hernia.

<u>10.</u> Bronchitis.	<u>1.</u> Deficient abdominal wall.
<u>41.</u> Whooping Cough.	<u>1.</u> Post Pneumonic.
<u>11.</u> Constipation.	<u>1.</u> Jumping off a table.
<u>47.</u> Crying.	<u>1.</u> Getting up after previous operation.
<u>2.</u> Hereditary. Brothers.	<u>1.</u> Rickets.
<u>1.</u> Diarrhoea & Vomiting.	<u>2.</u> After measles.
<u>63.</u> (Phymosis.) (Straining?)	<u>2.</u> Indigestion.
<u>3.</u> Carrying baby.	<u>1.</u> T.B. Peritonitis.
<u>1.</u> Recurrence.	<u>2.</u> Premature Birth.
<u>1.</u> Upon Walking.	<u>1.</u> Slipped on wet floor.
<u>8.</u> Fall.	<u>1.</u> Leg pulled through railing.
<u>3.</u> Injury.	<u>1.</u> Gymnastics.
<u>1.</u> Hiccough.	

In 207 Cases the supposed cause of the hernia was stated as given.

Experiments have been carried out in which, by increasing the intra-abdominal pressure, attempts were made to produce a hernia through one of the usual hernia apertures. These experiments have produced no definite result. They were performed upon the dead body, and curiously enough one of the factors which presented/

presented the greatest difficulty in carrying out these experiments, was the difficulty of obtaining a mesentery long and elastic enough to permit one to bring the intestine to a sufficiently low level. Upon the living subject the elasticity of the mesentery may be greater. But it raises the question what part an unduly long mesentery may play in the production of hernia.

Long Mesentery.

The average length of Mesentery is 8". It varies greatly; in three cases it was 5.7" and 10" long. It was longest in infancy and in those who had protruberant abdomens, e.g. Lockwood's case;—woman with protruberant abdomen but no rupture; Mesentery = 11 inches.— The height of the attachment of the mesentery is important. The mesentery of a strong, young, healthy person has such sturdy root attachments that it cannot be dragged downwards. It is fixed by a firm fibromuscular band which springs from the right curve of the diaphragm, and is inserted into the Duodeno - Jejunal Flexure; the muscle of Treitz; its fibres spread out with the branches of the sup. mesenteric artery. It is in reality the suspensory muscle of the Duodenum and mesentery. The suspensory muscle is far stronger than is needed to support the weight of the intestine and mesentery, which only weigh 26 ounces. Its function is to resist the downward displacement of the intestines during/

during the descent of the diaphragm and probably to assist the abdominal muscles in retaining their position during expiration. In congenital hernia the mesentery is fixed by a strong suspensory muscle at its proper height.

In talking of a loose mesenteric attachment, Rose and Carlless, p. 922, say:- "In old and weakly people, an additional cause may be found in the slipping downwards of the mesenteric attachment, causing the intestine to occupy the lower part of the abdomen rather than the upper, so that the former bulges out over the pelvic brim. This is possibly due to weakening or relaxation of the unstriated muscular tissue which normally exists behind the peritoneum, passing from the post abdominal wall to the base of the mesentery. It is sometimes called the 'Muscle of Treitz'."

Abdominal Pressure.

It is a matter of indifference whether the pressure in the abdominal cavity is perpetually positive or not. The pressure is increased normally, only when the abdominal muscles contract all together. Under the influence of abdominal straining the space is accidentally diminished, and the viscera escape towards those regions which are not diminished in size by the muscular pressure. This sliding away of the intestines will be/

be more forcible the more sudden the muscular contraction; e.g. an attack of coughing; this is illustrated while watching a hernia come down during an attack of coughing, or by placing the hand in the rectum or vagina. The effect of the increased pressure depends largely upon the position of the body and the degree of contraction of individual groups of muscles.

Certain individuals assume a position which places the minimum amount of tension upon weak spots and they also avoid other harmful influences.

The accidental force is applied, as a rule, in an unexpected and awkward position. The uncomfortable feeling in the lower part of the abdomen when one attempts to lift a heavy weight, is due in all probability to stretching of the peritoneum. The resulting influences may be minimal at the time, but repetition finally results in hernia. A harmful case may act many times without damage, eventually the peritoneum is loosened, then a slight bulging occurs and finally a hernia is formed.

We have mentioned straining upon micturition as one of the causation factors in hernia. The following taken from Professor J. E. Guaser's paper is of interest:-

Difficult Urination.

Difficult/

" Difficult urination is also of importance. Ravoth, Schmid, Karewsky, claim that phimosis is a predisposing cause in children - whereas Englisch, B. Schmidt, and others, deny any connection between the conditions.

It is not the obstruction to the passage of urine, but the irritation to the glans and prepuce which is associated with the desire to pass urine and straining when there is very little urine in the bladder."

Rose and Carless, in talking of the relation of constipation to hernia, say:- "Chronic constipation is a frequent factor in its production (Hernia), especially if the patient makes use of a closet with a high seat, whereby the inguinal canals are left unprotected. In uncivilized races when defaecation is performed in the squatting position, the lower part of the abdomen is supported by the flexed thighs and hernia is very uncommon. Patients with weak and bulging inguinal canals may with advantage use a low commode.

2. Congenital Malformation of Abdominal Wall.

Under this heading we do not include such developmental features as preformed pouches and sacculations of/

of the peritoneum, but rather the grosser errors of development. We may dismiss the subject very briefly. One case only has been seen by us. The patient was a boy, 1 year and 3 months old, suffering from Double Inguinal Herniae of large size. In addition, he had a marked condition of Epispadias with a low umbilicus and a large umbilical hernia. His external rings upon both sides were sufficient to admit the tips of two fingers. There were no inguinal canals to speak of, and internal and external rings were practically upon the same level. When an operation for relief of the hernia was performed, we found a thin external oblique practically amounting to little more than a fascia. The conjoined tendons were absent; the internal oblique and transversalis not descending to such a level: Needless to say that in such a case there was a post operative recurrence.

Such gross errors of development must be classed as Pathological Rarities and the question of their occurrence can never play an important part, fortunately, in the occurrence of hernia.

Ferguson, of Chicago, (Modern Operation for Hernia, 1907), believes that such cases as the above are comparatively common, not in the matter of the grosser deformation, but in the maldevelopment of the internal oblique/

oblique. He believes that such defective development is the most common cause of inguinal hernia, a view with which we cannot for one moment agree. All the cases from which our results have been deduced underwent the additional scrutiny provided by a surgical operation, and any such developmental errors could not have passed unnoticed. And surely children would be "par excellence" the choice of their occurrence. Our view upon the subject may be summarised briefly as follows:-

The Inguinal canal is the weakest point in the abdominal wall, the wider it is and the straighter its course, the more easily will a hernia develop in the region. A large external ring is of no special importance though it often means a large canal.

3. The Question of a Preformed Sac.

This, as a factor in the etiology of hernia, owed its introduction to the genius of Hamilton Russell, who, as early as 1899, at a Brisbane Medical Congress, introduced and enunciated the following propositions:-

- A. That oblique inguinal hernia is invariably caused by the pressure of a congenital sac, which in the vast majority of cases is provided by patency of the whole or a portion of the processus vaginalis.
- B. That there is no evidence in favour of the view that/

that congenital weakness of the abdominal wall in the inguinal region is a factor in the causation of inguinal hernia.

- C. While actual weakness of the abdomen in the inguinal region is frequently met with and may be an occasional cause of recurrence after operation, such weakness is not congenital, but is an acquired weakness due to the existence of the hernia for a prolonged period.
- D. Complete removal of the sac, when performed before the abdominal wall has sustained such damage, will not be followed by recurrence, it is furthermore the only treatment which is in the true sense Curative.
- E. It follows from the foregoing that the use of a truss (except in the case of very young infants) - is an improper method of treatment and that the only permissible course to advocate for every case of hernia in a child is operative removal of the sac - the sole cause of the hernia.

Only ⁱⁿ the first of these statements does he deal with the question of the congenital origin of hernia; but at the Hobart Congress (1902), he produced a great weight of evidence in favour of congenital origin, more especially in application to femoral hernia/

hernia.

Russel's deductions have become almost classical in importance, and we shall now give a brief resumé of his work, gleaned as it has been from his Presidential address upon the congenital origin of hernia, delivered before the Medical Society of Victoria on January 6th, 1904. (Lancet, March, 1904).

His attention was first directed to the subject by noticing a case of sacculated hydrocele occurring in a boy of 9 years. The hydrocele was continuous with the peritoneal cavity and shewed a curious sacculated or pouched outline. Such sacculations were undoubtedly purely congenital in origin and they furnished Russel with the groundwork of his theory. His next clue was picked up in the field of embryological research. He attempted to shew that the formation of the extremities from embryological buds was accompanied by a pouching of the peritoneum at the seat of budding.

He demonstrated the relationship which existed between the distribution of the superficial arteries from the common femoral and the position of the sac in femoral hernia; and at this time formulated the following Law of Hernia:- "The variations observed in the clinical manifestations of hernia are mainly determined/

determined by the site and position of the sac."

These facts, as we have said, were more especially for application to femoral hernia.

Inguinal hernia he associated with the occurrence in every case of a patent processus vaginalis. He drew attention to the false place which the term "congenital" occupied in the nomenclature of hernia. He suggested that the terms complete and partial funicular be substituted. The varying varieties of inguinal hernia owe their origin, according to Mr Russell, to corresponding varieties of sacculation of the peritoneal pouch. Thus he accounts for the interstitial and pro-peritoneal herniae by supposing that a portion of the descending peritoneal sac has become caught by the developing abdominal wall, and he looks upon the connection of an interstitial hernia with an imperfect descent of the testicle as the associated results of a common developmental cause.

Thus certain authors claim that the vaginal process is of importance in all cases of inguinal hernia. Others, on the other hand, hold that it is of no importance whatever, and bears no relation to inguinal hernia developing in later life. That a processus vaginalis exists in foetal life, no one doubts; the degree of obliteration which it afterwards undergoes/

undergoes varies considerably and it must be allowed that it is uncommon to have a perfectly free communication in later life between the tunica vaginalis and the peritoneal cavity; in other words, a patent process^{us}_a vaginalis.

The processus is most apt to close at the scrotal end, and may remain patent in the region of the cord, even as far as the internal ring.

Francke found a congenital sac 18 times, i.e. in 28, 6%.

Beresowky, 35 cases in 124 = 35%.

Wood, 127 cases out of 370 = 33.3%.

SOME CLINICAL FEATURES.

Some Clinical Features.

We do not intend to state these at much length. Their presence is already sufficiently well known and recognised. We state a few of them in order to bring in some interesting statistics.

Side of Occurrence.

It is a universally accepted fact that the majority of inguinal herniae occur upon the right side, and the occurrence has been understood to depend upon an anatomical basis, namely, that the testicle of the right side descends at a later period as compared with its fellow of the left side, the result being that the processus vaginalis is delayed in its closure upon the right side.

We found that 62% of the herniae were right sided. 24.5% were left sided and 10.5% were double, while in 3% of the reported cases the side was not mentioned:-

Side.		Number.
Right		619.
	Left	244.
Double		107.
Side not stated		30.

Total 1000.

With reference to the side affected, it is interesting/

interesting to note that in boys the hernia was right-sided in three cases out of four, while in girls it was right-sided in two cases out of three. This marked preponderance of right-sided hernias in boys is accounted for by the later closure of the vaginal process on that side:-

The Relation of Sex to Side.

Male Hernias.

Right Side = 577 or 65%

Left Side = 211 or 23%

Double = 97 or 10%

Total 885.

In male hernias 65% are right sided,
23% are left sided, and
10% are double.

The following table applies to female hernias.

Female Hernias.

Right Side = 42 or 50%

Left Side = 33 or 38.8%

Double = 10.

It is interesting that when we consider the female hernia cases by themselves, 33 cases out of a total of 85 or 38.8% are left sided;

While in male hernia only 23.8% are left sided.

Circumcision/

Circumcision in relation to Inguinal Hernia in Children.

The view, that increased abdominal pressure plays a powerful part in the etiology of hernia, is borne out by the fact that it is an almost general rule to recommend circumcision in all cases of inguinal hernia occurring in male children. If there is the least suspicion of phymosis, one supposes that in this way a great source of straining is removed.

Statistics, however, would not appear to bear out this relation. We found that as many cases were uncircumcised as circumcised.

In 470 Cases there was a history of Circumcision.

426 Cases were uncircumcised.

16 Cases shewed no record.

Practically 50% were circumcised, and

50% were uncircumcised.

Type of Sac.

We have not been fortunate enough to meet with many of the rarer types of sac. A single instance of an interstitial sac was the only one which ventured out of the beaten track. The others we classified as either funicular or vaginal. We found that the funicular sac occurred in 94% of cases, while the vaginal sac occurred in 4.1%.

Funicular/

Funicular = 948.

Vaginal = 48.

Type not mentioned = 10.

Interstitial = 1.

We were curious to know whether vaginal sacs had a greater preponderance of occurrence upon the right side. Our labour was sufficiently rewarded when we found that 81% of vaginal sacs occurred upon the right side. The exact numbers were as follows:-

Vaginal Sacs in relation to the Side upon which they occur.

Right side = 40.

Left side = 8.

Contents of Sac.

Condition.

In two of the cases the hernial contents were not seen; in others, the nature of the contents could only be approximately judged by passing a long pair of dressing forceps through the neck of the sac and withdrawing the contents which lay at the sac neck. The condition, of course, could always be judged. The following table expresses what we found:-

Reducible = 953.

Irreducible = 31.

Strangulated = 14.

Hernia not seen = 2,

or/

or expressed in percentages, 95% were reducible;
5% were irreducible; and 1% was strangulated.

Nature of Contents.

The table of contents of male hernias has been prepared from the state of affairs actually found at operation. In 762 cases the sac was found to be empty and its original contents could only, of course, be guessed at.

<u>Contents of Sac.</u>		<u>Male Cases.</u>
<u>Small Intestines</u>	=	<u>41.</u>
<u>Caecum & Appendix</u>	=	<u>56.</u>
<u>Sigmoid Flexure:</u>	=	<u>2.</u>
<u>Trans Colon</u>	=	<u>1.</u>
<u>Omentum only</u>	=	<u>27.</u>
<u>Fluid</u>	=	<u>5 cases.</u>
<u>Tubercular sac</u>	=	<u>12 Cases without</u> <u>sign of T. B. Peritonitis.</u>

One need only remark upon the comparatively large proportion which, in children, contain the caecum and appendix. We have already shewn the important relationship which this bears to strangulation. Two cases contained such an extraordinary medley of structures that we give the particulars separately:-

A. The first case contained caecum and appendix: part
of/

of ascending colon: small intestine: and Trans
colon: the latter was attached for two inches down
the inner and post wall of the sac.

B. The Second Case, contained caecum and appendix: a
quantity of small intestine: the trans-colon: the
transmeso - colon was also present and shewed an attach-
ment to the post wall of the sac.

Female hernias contain a greater variety of
 structures:-

<u>Ovary and Fallopian tubes</u>	=	<u>25.</u>
<u>Ovary, Fallopian Tubes & Uterus</u>	=	<u>2.</u>
<u>Caecum, appendix, ovary & tube</u>	=	<u>3.</u>
<u>Fallopian tubes alone</u>	=	<u>3.</u>
<u>Small intestine</u>	=	<u>3.</u>
<u>Omentum alone</u>	=	<u>4.</u>
<u>Omentum & Ovary</u>	=	<u>3.</u>
<u>Tubercular Sac</u>	=	<u>3.</u>

In a number of cases the sac, when opened, was apparent-
 ly empty. Usually, however, the attachment of the
 infundibulo-pelvic ligament could be seen as a thin
 peritoneal band upon the post sac wall. When this
 was pulled down, the tube, or ovary, or both, invar-
 iably appeared.

Contents of Sac in relation to Irreducibility:-Irreducible Hernias = 33.Containing small intestine = 3.Containing caecum & appendix = 22.Faecal loaded intestine = 5.Containing ovary & tube = 0.Containing only omentum
adherent to sac = 3.MORTALITY out of 1000 Cases.Causes. Ch Cl₃ poisoning = 2.

Bronchopneumonia = 2.

Convulsions = 1.

Thrombosis of Mesenteric
Vessels = 2.

Marasmus = 1.

THE TREATMENT OF INGUINAL HERNIA.

TREATMENT OF INGUINAL HERNIA.

History is always interesting, and none more interesting than that of medicine. From Manley's "Essay upon Hernia," we have taken the following interesting extract:-

"Old Prescription for Hernia."

Herniae. Thomas H. Manley.

"Guy de Chaubiac of Montpellier treated herniae by astringent plasters and other opeial applications, as the white of an egg for a vehicle, crushed nut galls, alum, antimony, yellow amber, etc. For a special species the following mixture was supposed to possess great virtue:- Turpentine, Litharge, Eagle's Faeces, human blood, ram's hair; blended together in rain water and vinegar."——

It bears out well the axiom that "Knowledge spells simplicity." To these old physicians a rupture was an immense thing; a lump which came and went, and which sometimes underwent a ghostly change, from which the sufferer died. They read the proverb that "desperate diseases require desperate remedies" in a true sense, and backed up the lack of this knowledge by the multiplicity of their charms.

The/

The present treatment of oblique inguinal hernia is usually one of two kinds:-

- A. Palliative.
- B. Operative.

The first is usually considered to be synonymous with treatment by a truss. But other methods of palliative treatment are in use. In the Yale Medical Journal for February 1904, Dr J.W. Seaver recommends exercises in the treatment of inguinal hernia in the young, a method which does not seem to have received attention previously. The rationale is obvious and depends upon the fact that the greater the development of the abdominal muscles, the less likely that any of the abdominal contents should pass along the canal. Dr Seaver believed that, by practice, a patient can learn to contract any part of his abdominal wall, and, with a view to developing this power, he introduced a number of exercises, the most important of which are:-

A. Lying on the back on a rug with a thin cushion under the head, the right knee is raised and drawn to the chest as close as possible, then the leg is extended and the same movements are performed with the left.

These movements are repeated 5 or 6 times. Then both knees are raised towards the chest and the pelvis from the floor, placing the hands palm downwards under the hips. These movements are likewise repeated.

B. Lying on the back, the feet are drawn up to the buttocks, and then the hips are raised from the floor as far as possible, bearing the weight on the feet and shoulders.

C./

C. The right leg is raised to the perpendicular, keeping the knee as straight as possible, the left leg lying straight on the floor and the hands, palm downwards, being below the hips; this is repeated on both sides, then both legs are raised to the perpendicular, an equal number of times.

D. Standing erect with head and hips held well back; the patient inspires deeply and at the same time retracts the lower abdomen as much as possible; then he relaxes the abdominal wall and expires. He repeats this from five to ten times, and while contracting the lower abdomen, pushes out the upper. Then he reverses the movement, contracting the upper abdomen and causing the wave of contraction to pass downwards over the abdominal wall.

E. Lying in the horizontal position, the patient raises the body to the sitting position, keeping the neck well extended.———

In the hands of Dr Seaver, this treatment has achieved excellent results, and, after a period sufficiently long to test the permanent value of the treatment, he gives the percentage of cures as amounting to 75%.

The idea appears to us an eminently sound one. Consider for a moment the mode of action of the inguinal canal and its associated muscles; an action such as is best seen during an operation for hernia, when the patient coughs or strains. In a muscular subject/

subject the fibres contract with such force that they actually expel a finger if it be placed in the canal. What happens is, that the front and back walls are powerfully brought together, and, at the same moment, the arching fibres of the internal oblique and transversalis shorten and descend upon the spermatic cord, pressing it down upon Poupart's ligament, and so obliterating the gap which would otherwise exist between them and this structure. Poupart's ligament also takes a share in closing the ring, at least it forms a slight curve with its convexity downwards towards the thigh, and when the external oblique contracts it becomes straighter and more rigid and is nearer to the arching fibres of the internal oblique and transversalis.

Such is an outline of the muscular action of the canal, and, when thoroughly developed, these muscles must be capable of enormous power. Proper development would at least assure that no contents were passed down the canal. A patent process might exist, but its presence would be of little consequence; a functionless process, such as it would be, would quickly contract and atrophy.

This mode of treatment owes its origin to America, and does not seem, in this country at least, to have attracted/

attracted the attention it demands.

As a method of treatment, it requires more perseverance than many people can exercise, and the success, or otherwise, will largely depend upon the care, time, and attention which is given to it.

In the case of children, the matter of course depends largely upon the parents under whose supervision the treatment is carried out.

Treatment by Trusses.

The very excellent results which operative treatment now yields are fast abolishing trusses as a mode of treatment. This fact, while more or less true in all hernias, is especially applicable to the inguinal hernia of children. The question of whether a truss really ever produces a cure is a doubtful one, and with it we shall deal later. But, assuming for a moment that such a cure is a possible attainment, just imagine what it really means.

Mr MacAdam Eccles, one of the strongest advocates of the use of trusses, says in a recent monograph :-
"The permanent closure of the processus vaginalis will be obtained in the majority of cases only after the continuous action of a steel spring truss over a period/

period of some years. The truss, carefully adjusted,
must be worn by the child continually, day and night,
sleeping and waking, crying and peaceful." Or again,
 Langton says:- "When the protrusion takes place before
the age of 1, the use of a truss should not be dis-
carded, under any circumstances, till the age of 4
years. If a truss has not been worn till the age of
3 or 4, it must be worn till the age of 10; if not
worn till the age of 7, then the truss should be worn
till puberty." Surely an exacting regime.

The other side of the question is certainly a brighter one. Operative risk, one may dismiss as non-existent for all practical purposes. - A few hours of discomfort, ten to fourteen days' rest in bed, and the child is then able to go about, cured of its hernia and free from the encumbrance of truss or bandage.

Lockwood, in his "Treatment of Hernia, Hydrocele and Varicocele", goes thoroughly into the question of operative treatment. His reasoning is so good that we give it in full. His paper, 1898, was written at a time when the operative treatment of hernia in children was still in an early stage of development. But, reading it in the light of to-day, one is able to dismiss his arguments contrary to operation, with the result/

result that it becomes an argument strongly in favour of operative treatment. He says:-

"Radical Cure in Children."

Children are not, from an anatomical point of view,
ideal subjects for Radical Cure. My statistics show
that, during infancy and childhood, the mesentery is
relatively long and the excursion of the intestines
relatively great. But still, in spite of this, the
fact remains that in infancy and childhood ruptures
usually get well if properly treated with a truss.

Obviously a truss should, when practicable, be
tried before an operation is done. The delicacy of
the tissues, especially of the vas deferens and
spermatic vessels, is an additional reason for avoiding
all but necessary operations in infancy. These
structures are usually adherent to the sac, and in
this attempt at separation I have more than once seen
the vas deferens divided and the vessel torn. Never-
theless the operation is attended with such slight
danger to life, and usually succeeds so well in
children, that I do not hesitate to perform it when
an adequate reason appears.
At the age of 8 or 9 years the tissues are fully formed
and can be safely manipulated."

We shall now discuss the question as to whether
a truss really ever produces an actual cure.

In a healthy child, the obliteration of the processus vaginalis or funicular process takes place only a short time before birth. "Certainly during the last month of foetal life, and generally within the last two weeks." (Evans).

The obliteration begins at the proximal end of the process and travels downwards, and at birth, in practically every child, the process is still partly unclosed. In the economy of nature the process of obliteration is not arrested here, but continues to progress during the first months of life and even until the child is twelve years old. In the course of operation for inguinal hernia in children, one is constantly coming across such cases, and among the thousand cases which form the theme of this thesis, we have come across 34 such cases.

One has heard it stated time and again that the process of spontaneous cure has arisen as the result of the continuous pressure of a well fitting truss. Such an impression is entirely wrong. The obliteration of the process has no relation whatsoever to the wearing of a truss, as the accompanying statistics will/

will shew. Our first object was to find out the actual frequency with which trusses were worn.

In 346 cases there was a distant history of a truss having been worn.

In 645 cases there was a distant history of no truss having been worn.

In 9 cases no mention of a truss was made.

Our next object was to find out the proportion of cases which showed a process of spontaneous cure, and we found:-

In a total of 1000 cases, 34 cases showed the power of spontaneous cure. = 3.4%.

The crux of this matter lay in what relation these 34 cases had to a wearing of a truss. The following are the cases:-

Age.	Sex.	Truss.
10 ¹ /27	M	X
2 yrs.	M	X
17/12	M	O
3	M	X
3/12	M	O
11/12	M	O
111/12	F	X
8/12	M	O
29/12	M	O
7/12	M	O
93/12	M	O
210/12	M	X
18/12	M	O
4/12	M	O
4 yrs.	M	O
4/12	M	O
5 yrs.	M	X
34/12/		

Age.	Sex.	Truss.
3 ⁴ / ₁₂	M	0
3 yrs.	M	X
4 ¹ / ₁₂	M	0
8 ¹ / ₁₂	M	0
9 ¹ / ₁₂	M	0
19 ¹ / ₁₂	M	0
8 ¹ / ₁₂	M	0
17 ¹ / ₁₂	M	0
6 ¹ / ₁₂	M	0
5 ¹ / ₁₂	M	0
28 ¹ / ₁₂	M	X
6 ¹ / ₁₂	M	0
3 ¹ / ₁₂	M	0
7 yrs.	M	0
8 ¹ / ₁₂	M	0
10 ³ / ₁₂	M	X
2 yrs.	M	0

In these 34 cases only nine shewed a history of a truss having been worn. Surely such is obvious proof of the fact that the wearing of a truss bears no relation to the spontaneous cure of an inguinal hernia.

Operative Treatment.

There can be little doubt that this is, in children, the best method of treatment. Stiles, in the B. M. J. October, 1904, says:-

"If it be true that the majority - some say all - of inguinal hernias in young and middle life are of congenital origin, it seems to me that it is clearly the duty of the surgeon to step in and cure the hernia once/

once and for all at a period of life which is at once the most suitable from the point of view alike of the patient, the relations, and the surgeon. By operating during infancy or childhood the patient is not rendered "hors de combat" at a period of life when he is a useful member of the community; if belonging to the poorer classes, the wife and family do not suffer from the interruption of the weekly wage, nor is the drain upon the hospital charity so great. In the upper classes the advantages are equally on the side of operation in early life."

While the majority of surgeons are of one mind as to the advisability of operating, great differences of opinion are held as regards the best time for such.

Evans, in a paper upon the treatment of inguinal hernia in children, (Lancet, Jan. 1909), says:-

"In the ordinary case of congenital hernia it is usually unnecessary, in my opinion, to advise the performance of an operation during the first year of life, for during the greater part at least of that time a non-operative cure is still possible, and even if it is not likely, the general health of the child may make it advisable to postpone operative treatment."

The surgeons who now-a-days do not approve of the/

the operative treatment of inguinal hernia in children are practically non-existent, but there are many opinions as to the age which is most suitable for operation. For example, we have quoted Mr Evans's paper in the Lancet, 1909, where he says it is unnecessary to advise the operation before 1 year of age. We take the view that age is no bias to the time at which operation should be performed. We argue something like this: the majority of hernias in children are of large size and, in the great proportion of cases are enteroceles, which are exceedingly difficult to combat by a truss. Every time the child strains or cries, a loop of bowel or contents are found along the inguinal canal, stretching and distending its muscular arrangement. This procedure repeated day after day, may be hour after hour, results, by time, in a chronically lax and distended inguinal canal with weak and thin muscles; all this occurring, too, just at a time when the inguinal region is completing its development.

We would note that, after say the first three months, the sooner a hernia is operated upon the better. The operation, as we describe it, is of such a nature that practically no interference is played with the inguinal canal or rings.

Table to show age at which operation was performed:-
Months.

Age during which op. was performed.		Number.
Months	1	Number 1. $\begin{cases} M \\ F \end{cases}$
Months	2	Number 7. $\begin{cases} M & 5 \\ F & 2 \end{cases}$
Months	3	Number 22. $\begin{cases} M & 20 \\ F & 2 \end{cases}$
Months	4	Number 52. $\begin{cases} M & 46 \\ F & 6 \end{cases}$
Months	5	Number 48. $\begin{cases} M & 47 \\ F & 1 \end{cases}$
Months	6	Number 48. $\begin{cases} M & 44 \\ F & 4 \end{cases}$
Months	7	Number 35. $\begin{cases} M & 33 \\ F & 2 \end{cases}$
Months	8	Number 41. $\begin{cases} M & 37 \\ F & 4 \end{cases}$
Months	9	Number 19. $\begin{cases} M & 18 \\ F & 1 \end{cases}$
Months	10	Number 26. $\begin{cases} M & 25 \\ F & 1 \end{cases}$
Months	11	Number 17. $\begin{cases} M & 16 \\ F & 1 \end{cases}$

Table to demonstrate the Ages at which the Operation was performed:-

Years 1 to 12.

Period during which operation was performed.	Number.
Age between 1 & 2 years	153 { Male 140 Female 13.
Age between 2 & 3 years	97 { Male 90 Female 7.
Age between 3 & 4 years	54 { Male 48 Female 6.
Age between 4 & 5 years	24 { Male 21 Female 3.
Age between 5 & 6 years	33 { Male 23 Female 10.
Age between 6 & 7 years	24 { Male 20 Female 4.
Age between 7 & 8 years	16 { Male 11 Female 5.
Age between 8 & 9 years	11 { Male 5 Female 6.
Age between 9 & 10 years	15 { Male 10 Female 5.
Age between 10 & 11 years	13 { Male 10 Female 3.
Age between 11 & 12 years	10 { Male 7 Female 3.

We have drawn up tables which may be of some interest in so far that they shew the ages at which operation was performed.

During the first year of life operation was most commonly performed about the fourth month; but during the 4th, 5th, and 6th months the operation rate kept wonderfully constant. As regards the years, the period between the 1st and 2nd easily head the list; the second year closely follows it, but thereafter the numbers diminish annually until the limit of 12 years is reached.

The question may be asked why the first year of life should be the one in which the operation is most commonly performed. The answer is most likely to be found in the fact that at this period the child is beginning to walk; the hernia, not previously noticeable, may now appear. Or if it has been previously noticed, its presence may now begin to cause some inconvenience.

H. Batham Robertson says that the term taxis is usually limited to the manipulation when the hernia fails to return as it should. He insists that, for safety's sake, operation is the ideal method of treatment, i.e., an inspection of the contents of the sac.

As complete abolition of taxis is not likely to be accepted/

accepted entirely, he mentions the methods:-

- " A. By relaxation of the tense structures pressing on the sac.
- B. By rendering tense the structures pressing on the sac."

With experience the manipulation of a few minutes will decide whether reduction is likely to take place or not."

He then proceeds to enumerate a long list of bad results which may follow taxis:-

- "A. Extensive bruising, shown by haemorrhage into the bowel, accompanied by diarrhoea.
- B. Subsequent gangrene, produced by rough handling.
- C. Tear at seat of constriction, produced by rough handling.
- D. Infection of peritoneum by contents of sac.
- E. Exit may be gangrenous.
- F. Process of ulceration may be so deep that perforation occurs almost immediately.
- G. Reduction may not be complete, a small knuckle of bowel being nipped down in the ring.
- H. Rupture of sac on distal side.
- I. Reduction "En Bloc."
- J. Bilocular sac, the contents being reduced from one sac into another."

(Brit. Med. Journ. Jan. 5, 1909).

H. S. Clogg states that in children the inguinal variety of herniae occurs more frequently than any other. Inguinal herniae he divided into two varieties, the direct and the indirect. He has not seen a case of direct inguinal hernia in a child.

J. C. Hubbard, M.D., published in the Annals of Surgery, 1901, a paper which he entitled "The Worstest truss in Inguinal Hernia"; many of his remarks are of great interest. He says:-

"The treatment of inguinal hernia in infants and young children presents quite a different problem from that of adults. . . . The truss treatment offers in the infant a greater hope of cure than in the adult, because of the active growth of the child's body. In the latter, the tissues are normally building in excess of wear and tear, hence the probability provided the hernia can be kept reduced is greater that the ring will close and a cure result!" The truss which he employs is an ordinary worsted one, white, about 4 ply in thickness. His method of application is as follows:-

"The child is placed on the back, the half skein is passed under him and pulled far enough that the end just reaches the internal ring. The other end is passed through the loop and the hernia reduced. The bunch/

bunch of worsted made by the looping is carefully and firmly adjusted over the hernial opening. The free end is passed under the leg and fastened by a piece of bandage to the truss at the back.

The success depends upon the intelligence of the mother and the care with which she carries out the instructions. The truss should fit snugly and must be worn night and day. Whenever it is to be changed the child must lie down."

He concludes with instructions upon the length of time which the wearing of the truss should be continued:-

"The length of time which a truss must be worn to cause a cure varies with different writers. Kocher says that if during the first months of life the hernia can be kept back for a matter of weeks, a cure is brought about; and that if the child is over 6 months the truss must be worn for 3 to 12 months."

Colny considers that the truss has not had a fair trial unless it has been worn one or two years. He prefers a spring truss.

THE OPERATION FOR THE RADICAL CURE OF INGUINAL

HERNIA.

THE OPERATION FOR THE RADICAL CURE OF INGUINAL
HERNIA.

As regards the operation which, as a routine, is performed at the Edinburgh Sick Children's Hospital, it is based upon the belief that in all the hernias of children, the fault lies neither in the muscular arrangements of the inguinal canal nor of its rings, but in the possession of a patent sac, whether congenital or acquired. Conversely the operation is directed towards an eradication and possible prevention of the patent sac, without in any way interfering with the muscular arrangements of the part.

~~Stiles~~ says:- "Bassini's operation . . . is to be condemned as a routine operation in children."
(B. M. J. Oct. 1st, 1904).

In operating upon strangulated inguinal hernia this rule has occasionally to be somewhat modified. It is seldom necessary to slit up the anterior wall of the canal, the obstruction to reduction is usually situated at the external ring, and is caused by a constricting action of the arching fibres of the external oblique and sometimes of the transversalis muscles. A simple nicking of these fibres, with some slight degree of stretching, will dilate the ring sufficiently/

sufficiently to permit of reduction of the sac contents.

These remarks apply, of course, to inguinal hernia in the male. The principles may, however, be quite appropriately applied to female cases.

OPERATION.

An oblique incision is made downwards and inwards, parallel to Poupart's ligament, beginning one inch above mid. Poupart and ending just external to the spine of the pubis. This incision is carried through the tissues until the opening in the aponeurosis of the external oblique with the cord, comes into view. In the course of the dissection haemorrhage will probably occur from the superficial internal pudic artery, and in the outer part of the wound from the superficial circumflex iliac artery. The cord with its coverings can now be recognised as it passes out of the ring; with a dissection it is freed and brought out of the wound, frequently the testicle accompanying it. This stage is shown in the accompanying photograph. A second photograph is appended, in which it will be seen that the cords of both sides have been separated. Between these cords a distinct difference will be seen, that upon the left side being much thicker than the cord of the right side. This thickening/



PK(7)

First stage of dissection in hernia operation - the cord and coverings of the right side are exposed.



P(77)

This photograph demonstrates the difference in calibre between a cord which contains a hernial sac and one which does not - that upon the left side contains a hernial sac.

thickening is due to the existence in the cord of a patent hernia sac.

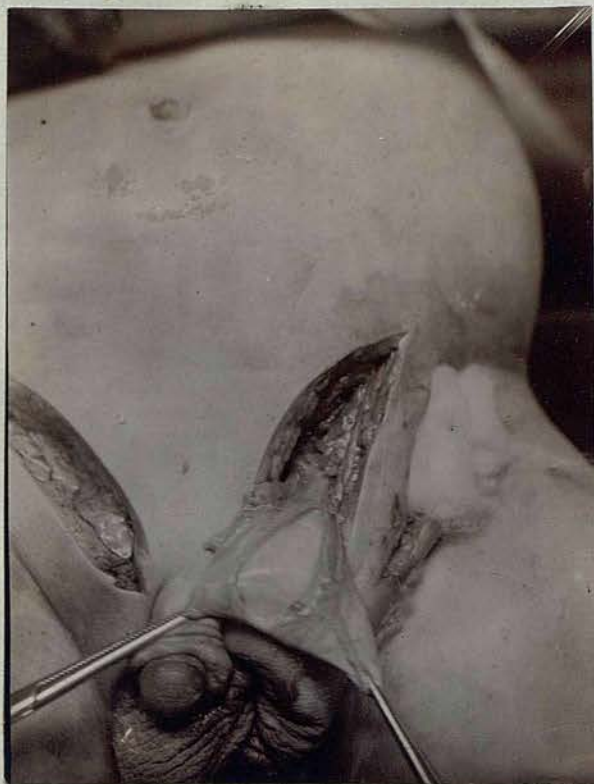
The cord having been thoroughly freed and brought well out of the wound, one then proceeds to have the coverings of the cord well on the stretch in preparation for the next stage of the operation, namely the division of the coverings. This, as the photograph shows, is done by clamping the ends laterally with Kocher's artery forceps, and holding them well apart. In this way the coverings are rendered taut and are easily divided. This division is carried out with a sharp knife, and the intercolumnar and cremastic fascia are in their turn divided.

The photograph shews the condition of affairs after division of the cremastic fascia.

The sac now comes into view, its pearly white wall shining through the infundibuliform fascia. Upon its postero external aspect one can detect the vessels and the vas as they pass downwards.

If one now begins to separate the vas and the vessels, difficulties immediately arise, in fact ~~part~~ one is unable to separate them properly.

Something further is required, namely division of the infundibuliform fascia which binds both sac and/



P. (17)

This photograph has been taken to shew the method of keeping the coverings taut while they are being divided - the external spermatic and cremasteric fascias have been divided.



P. (J. 2) :

This photograph has been taken at a later stage of the operation; the infundibuliform fascia has been divided and the veins and vas appear lying upon the hernia sac.

and vessels closely together. This fascia is next divided with a sharp knife when veins and vas are easily stripped off the sac.

The coverings of the sac have now been stripped aside and one can with ease differentiate sac, veins, and vas.

In the photograph they are shown as three separate constituents held apart upon the fingers.

To facilitate manipulation of the sac it is well to clamp it low down with forceps, the distal portion being either removed or thrust back with the testicle into the scrotum.

The next stage in the operation is probably the most important of the series, it consists in the thorough separation of the sac from its coverings, practically as far as the internal abdominal ring ; for this procedure a sharp knife is "par excellence" the instrument to use.

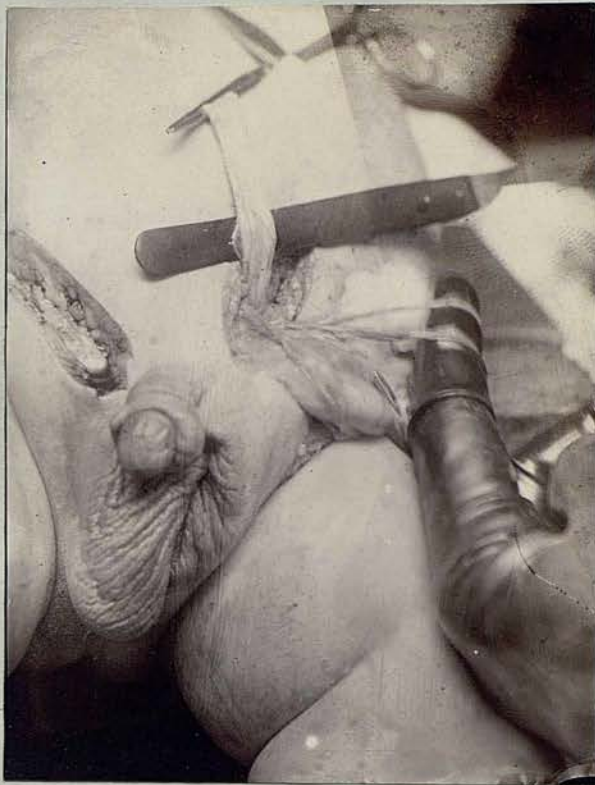
The photograph shews the separation upwards of the sac, the veins and the vas being meantime held out of the way. (This separation upwards of the sac is important because, were it not carried out, the stump of the sac could not possibly slip back properly, but would be anchored by the attachment of the infundibuliform fascia to the transversalis).

The/



P.(J.2)

Sac, veins, and vas are dissected free and are being held apart.



P.(J.H)

The complete separation of the sac is being proceeded with upwards as far as the internal ring, the vessels and vas are held aside by the fingers.

The removal of the sac is now proceeded with, but before such is done it is well to open the lumen of the sac and satisfy oneself that it is perfectly empty. The sac is then pulled well down and, as high up as possible, it is transfixed and ligatured with strong catgut; the distal portion is removed and the state of affairs is as shown in the accompanying photograph.

The ligature is still attached to the neck of the sac, and, after the division of the ligature, the sac stump will retract within the abdomen.

The operation is now practically completed and so far there has been no interference with the muscular arrangements of the canal. Should the external ring appear somewhat loose and enlarged, it can be narrowed in the following way:- using a fully curved needle and catgut, one or two stitches are put through the pillars of the ring; upon the inner side, picking up the conjoined tendon; when these are tied the external ring will be found to be sufficiently closed, and yet to exert no constricting action upon the cord or its vessels.

Any divided vessels must be carefully ligatured as haemorrhage in this lax tissue is apt to be progressive.

The/



P.(7.7.)

The sac neck has been ligatured and when the ligature is divided the stump will slip back within the abdomen.

The skin wound is closed with a mattress suture of silk-worm gut: it is useful in so far as it prevents serum accumulation in the wound. The skin edges are brought together by interrupted sutures of horse hair.

Moynihan gives the following indications for operation:-

1. In cases of Irreducible hernia.
2. In all cases where fluid is present in the sac.
3. In operation for the relief of Strangulated Hernia.
4. In all cases where it is impossible to retain and control the Hernia by mechanical means.
5. In cases where a truss has been worn for 3 and 4 years without benefit.

RECURRENCE AFTER OPERATION.

It seems rather paradoxical to talk of recurrence in the same breath with which we have discussed the "Radical Cure," and yet it is a possibility which no one can afford to overlook.

Even in the days of Percival Pott, the question was looked upon as a "Bete noir". Pott, in his Chirurgical Works, 1779, passes such a comment:-

"this uncertainty of event being dependent on causes which a surgeon can neither foresee nor direct with any tolerable/

tolerable degree of certainty, should warn him against being too forward in making a promise." And this "uncertainty of event" which existed in 1779 forms in 1909 just as strong a feature.

The question largely depends upon the length of time after the operation which one takes as a test of Recurrence. Vincenzo, (Rif. Med., January, 1908), takes a period of two years after operation as a test, although, if relapse is to occur, it usually sets in within a few weeks after the patient returns to work. Vincenzo made this remark while talking of hernias of adults. In regard to children it is a very safe rule, our experience has gone to shew, that if recurrence does take place, it sets in during the weeks of convalescence, while the patient is walking about.

Why should there be recurrence of inguinal hernia?
Again to quote Vincenzo:- "The most usual cause of relapse, apart from some violent force, is a general laxity and weakness of the abdominal supports; relapse is more likely to occur where there has been deep suppuration; it is uncommon in early and in late life. Excess of fat in the abdominal walls is not per se a cause of relapse, but as it is generally associated with weak and feeble muscular development, may for the latter defect be followed by relapse." Mr Battle rightly/

rightly points out that the presence of the cord is an important factor in recurrence:- "The importance of the presence of the cord is fully recognised by operators, for all will admit that recurrence is hardly known in the female." Yet it is not so much the presence of the actual cord as the anatomical peculiarities to which it gives rise. When we examined the interior of the anterior abdominal wall in its lower half, we found there a system of peritoneal pouches, viz., three fossae, which vary greatly in depth in different subjects, are formed on either side of the middle line close to Poupart's ligament. They are as follows:-

- A. The Internal, which lies between the folds formed by the ~~urachus~~ and the obliterated hypogastric artery; usually quite shallow.
- B. The Middle, narrow, but frequently deep; lying between the obliterated hypogastric and the deep epigastric artery.
- C. The External, lying to the outer side of the deep epigastric artery, and in its lower, inner, and deepest part corresponding to the internal abdominal ring.

To this last we would draw special attention. This external fossa - sometimes called the digital fossa/

fossa - constitutes, so to speak, the anatomical predisposing cause of inguinal hernia.

A further cause is in immediate relation to it. As the cord leaves the abdominal cavity and pierces the internal ring, it receives from the fascia transversalis a tubular covering known as the infundibuliform, or internal spermatic fascia. A careful dissection of this part will shew the presence of several bands of strong fibrous tissue, passing from the inner edge of the opening of the transversalis fascia and becoming fused with the infundibuliform fascia at a lower level - no doubt an integral part of the infundibuliform fascia, yet sufficiently well defined to be described as a separate band. If we now exert slight traction upon the cord, a very pretty phenomenon will be observed. The strong fibrous band already mentioned drags upon the transversalis fascia at the inner margin of the ring, this being closely connected by the extra peritoneal tissue to the peritoneum, transmits its action to the peritoneum, and, if we now examine the inner surface of the abdominal wall, we find that the external fossa has actually doubled its depth and is already beginning to pass along the cord as a patent process of peritoneum. Such constitutes the thin edge of the intra-abdominal pressure, and all traction/

traction influences tend to increase it, and gradually a complete patent sac is formed and the hernia has recurred - the very essence of an acquired sac.

This has an even more important bearing when we consider the relation which it bears to the operative treatment, for it stands to reason that, if such a strong predisposing feature to occurrence or recurrence lies at the internal ring, it will be necessary to as far as possible remove such a condition of affairs. Complete separation of the sac is the necessary feature. If this separation is carried so far, the anatomical peculiarities we have described are altered, and any tendency to ~~drag~~ upon the digital fossa is abolished.

In regard to the question of Recurrence of the Hernia after operation, we have been able to trace only 6 cases of these; 4 occurred during the first 360 cases. .6%.

Particulars:-

Case I. Boy, 2²/12 years old, previously operated upon for strangulated hernia when 10 weeks old; the operation necessitating division of the anterior wall of the canal in order to reduce the contents.

Case II. Similar case, Boy, in which an operation for strangulated hernia had previously been performed, while a baby.

Case III./

Case III. Boy, 1 year and 3 months old, who had in addition to a large double inguinal hernia, a condition of epispadias with a low umbilicus and umbilical hernia.

Case IV. Boy, 5 months old, in which a right inguinal hernia occurred. The operation of circumcision for a tight phymosis was neglected to have been done after operation. Straining on micturition continued and a small bubonocoele recurred at the site of the former operation.

Case V. Boy, 2⁷/12 years old, in which a left inguinal hernia recurred. The operation had been previously performed when the child was a few months old. At the second operation the upper part of the external ring was found to have stretched and through it a small pear-shaped sac protruded.

Case VI. Boy, 5 years old. Rickety, lax and weak muscles. At operation there was found to be a stretching of the muscular tissue within neighbourhood of the ring, (Left.) At the operation the site of the former ligature could be recognised, now forming a knot at the lower end of the sac.

It may be of interest to mention the experience of some surgeons as regards recurrence.

Pott/

Pott, in the Deutsche Zeitschrift für Chirurgie, 1903, Bd. LXX, published an article entitled "Zur Prognose d. Radikalen Operation d. Hernien." He mentioned that, out of a total of 4066 cases of inguinal hernia, 81.8% were absolute ones. He gave further statistics as regards the rate of recurrence after individual methods, but with these we shall not deal.

Championniere's results are more encouraging. He reports 96.7% of cases in a total of 650 cases.

Championniere, "Cure Radicale des Hernies, 1892." Bassini's Reports are sure to be of interest. They were published in the Transactions of the Italian Congress of Surgeons, 1888. The original Report gives 362 cases with 7 relapses, 4.98% of cures.

Brenner, Arch. f. Klin. Chir. 1906, Bd. 79, Hp. 4, gives a proportion of 91.8% as permanent cures; a total of 991 operations were performed.

STRANGULATED HERNIA.

Some authorities have stated that strangulated hernia never occurs in children.

Estcoer, (Strang. Hernia in Infants, Rev. de Chir. 1902, Nos 3, 5 & 6), prepared an elaborate inquiry into the matter, and after consulting Hospital records at Basle, Prague, Breslau, Vienna, Krakow, Frankfort, Amsterdam/

Amsterdam, Berne, and Gottingen, he found that among 139,000 cases occurring in children there was not a single record of herniotomy having taken place for strangulation. Such a record is quite exceptional, and in the accounts of hernia gleaned from any of the large children's Hospitals we found accounts of several cases of true strangulated hernias. Of course much depends upon the distinction which is drawn between strangulated and irreducible varieties; but if the first type is associated with an actual obstruction of the blood flow there ought to be no ambiguity in the matter. There is no doubt that the condition, as it occurs in children, is rare.

Stern gives the proportion in children as compared to that in adults as 1 into 108.

Tariel, after remarking that such noted surgeons as Holmes, Gosschen, and St. Germain have never met with acute cases requiring herniotomy, tabulates the records of 128 cases, all he has been able to collect.

Konig, during his long surgical career, only met with two cases, while Messhaum operated upon two in a total of 59,000 cases.

In a total of 1000 cases we have found records of 14 cases, distributed thus:-

Total number = 14.

Sex/

Sex.

Male = 13.

Female = 1 (Left side).

Side. Right = 12.

Left = 2. One being female.

Or expressed in percentages, an occurrence of 1.4%.

Etiology.

We must be prepared to admit that the etiology of strangulation as it occurs in children is different from that which occurs in adults.

Muscular action may play a part in it.

"The descent of the bowel was usually stated to have been caused by a severe fit of crying, and in one or two instances by straining at stool, or during micturition, more frequently the former. When the bowel is grasped by the walls of the inguinal canal a gripping pain is set up, which, by provoking further crying, forces more bowel down. No doubt, also, a further cause of irreducibility is the reflex contraction of the lower fibres of the internal oblique and transversalis muscles, which, along with Poupart's ligament, act like a half sphincter thrown into a state of spasm. The gripping pains in the bowel are generally so severe that vomiting sets in, and this again serves to aggravate the condition." Stiles, B. M. J. Oct. 1904.

Such/

Such cannot account absolutely for the condition, there must be some further causative feature.

Moynihan says:- "It is remarkable that operations are more frequently called for during the earlier months of childhood than during the later, the greatest number occur during the 1st, 2nd, and 3rd months of the first year; the proportion after this diminishes rapidly, as is shewn by comparing in a tabular form the cases operated upon in each of the first twelve months." Medical Encyclopoedia, Vol. 4.

To support his statement he appends a table which bears out the truth of it:-

During the 1st month 16 cases occurred.

"	"	2nd	"	15	"	"
"	"	3rd	"	14	"	"
"	"	4th	"	9	"	"
"	"	5th	"	4	"	"
"	"	6th	"	7	"	"
"	"	7th	"	3	"	"
"	"	8th	"	6	"	"
"	"	9th	"	9	"	"
"	"	10th	"	3	"	"
"	"	11th	"	3	"	"
"	"	12th	"	4	"	"

He offers, however, no explanation of this curious coincidence.

Our/

Our own observations are quite in agreement with Moynihan's. We tabulated the cases according to the age at which the strangulation was found to occur, and we found that, with one exception, all the cases occurred during the first year of life. The single exception was that of a child aged 18 months.

Age at which Strangulation occurs.

<u>1.</u>	<u>12 months.</u>
<u>2.</u>	<u>7 months.</u>
<u>3.</u>	<u>10 months.</u>
<u>4.</u>	<u>4 months.</u>
<u>5.</u>	<u>7 months.</u>
<u>6.</u>	<u>(1$\frac{1}{2}$ years).</u>
<u>7.</u>	<u>6 weeks.</u>
<u>8.</u>	<u>5 weeks.</u>
<u>9.</u>	<u>2 weeks.</u>
<u>10.</u>	<u>2 months.</u>
<u>11.</u>	<u>11 months.</u>
<u>12.</u>	<u>4 months.</u>
<u>13.</u>	<u>3 months.</u>
<u>14.</u>	<u>5 weeks.</u>

Such a relation cannot surely be a mere coincidence,^m and, upon carefully going over the records of these cases, we discovered some points which may throw some light upon the condition.

We/

We must first assume that the child possesses a preformed or congenital sac, in other words a patent processus vaginalis. It exists as an open receptacle into which a loop of bowel is ever ready to pass. As we have already mentioned, this patent process, during the early life of the child, continues the attempt at obliteration which has been already so long delayed, with the result that this obliterating change is seen as a gradual shrinking up or constriction in the circumference of the sac, so that upon slitting up the sac one finds a distinct narrowing of its diameter. Let us now suppose that a knuckle of bowel passes into such a sac. It may be arrested above the constricting ring, where its reducibility will remain assured. But, should it pass beyond the constriction, it is already on the way to irreducibility and later to strangulation. In our case records we have again and again proved this sequence of events, and it, of course, at once explains the relationship of the age to strangulation, for the first twelve months is just the period during which the sac constriction is most dangerous. It is neither one thing nor another. Obliteration, if it is to occur, has not yet become complete, and, should obliteration proceed/

proceed no further, the size of the constriction is just of a suitable size to seize and constrict the infantile bowel.

Such, to our mind, is the explanation of the occurrence of strangulation being confined to such an early age.

There is yet another point which one cannot overlook in dealing with the etiology of strangulated hernia, namely, the relation which the contents of the sac bears to strangulation. We found that out of 14 cases, 10 contained the caecum and appendix:-

Strangulated Hernia = 14.

Containing small intestine = 2. Great quantity.

Containing caecum & appendix = 10.

From torsion of cord with
undescended testicle = 1.

Containing omentum = 1.

Or, in other words, that 71% of strangulated hernia contained the caecum and appendix.

The exact mechanism of strangulation is still a debated point, and many theories have been put forward to explain its occurrence. The following are among the most important:-

Roser believed that strangulation was due to a valve-like/

like occlusion produced by the mucous membrane at the seat of rupture.

Busch's theory was that the fluid contents of the intestine were forced into the afferent loop producing angulation , which was the leading factor in the strangulation.

Lossen thought it was due to the compression of the column of faeces acting upon the vessels of the mesentery and producing venous stasis.

Kocher considered dilatation rather than angulation to be the important feature.

Reschel thought that the mucous membrane of the herniated loop was invaginated upwards and thus produced the strangulation.

Von Zwabenlung has recently carried out some interesting experiments, an account of which we abstract:-

"After aetherisation of an animal, a loop of intestine is pulled through an abdominal incision, a canula is tied into one end of it and an electric lamp into the other. The tissue is then brought under the microscope and changes in the circulation noticed, different pressures being obtained by introducing water through the canula into the lumen of the gut. The degree of pressure is marked by a mercury manometer placed in contact with the pressure bulb. At a pressure of

30 m.m. the circulation in some of the smaller lymphatics becomes arrested.

At 60 m.m. many of the smaller veins become stagnant.

At 90 m.m. the greater part of the blood stream stopped entirely, that which continued moving moved very slowly, the current passing now in one direction, now in another.

At 130 m.m. all circulation ceased.

As early as 50 m.m. small haemorrhages began to appear.

Gut kept at a pressure of 90 m.m. for 1 hour became enormously congested, small drops of fluid standing out on the surface of the gut like beads of sweat, illustrating thus how the serous exudate occurs!

Van Zwabenlung believes that this experiment demonstrates the importance of distention as a factor in the production of strangulated hernia, in other words, it tends to confirm Kocher's theory. (Keen, Vol. 4
8. 42).

Morbid Anatomy.

It is a curious fact that strangulation rarely passed on to gangrene. In none of the 14 strangulated cases was the bowel gangrenous; although frequently deeply congested, and of a dark purple colour, it was deemed/

deemed safe to ~~return~~ it in all cases. In one case, however, it was considered advisable to invert a small portion of the lumen of the gut.

In this special case, just where the gut was constricted by the constricting ring in the sac wall, there was an annular portion which looked very suspicious. It had not, however, quite lost its gloss. Another remarkable feature is the fact of how slowly the strangulation progresses. We have seen cases in which the contents had been irreducible for almost three weeks, and yet when the sac was opened the bowel was found to be still viable. It shows how different must be the etiology of this condition as compared with that of adults.

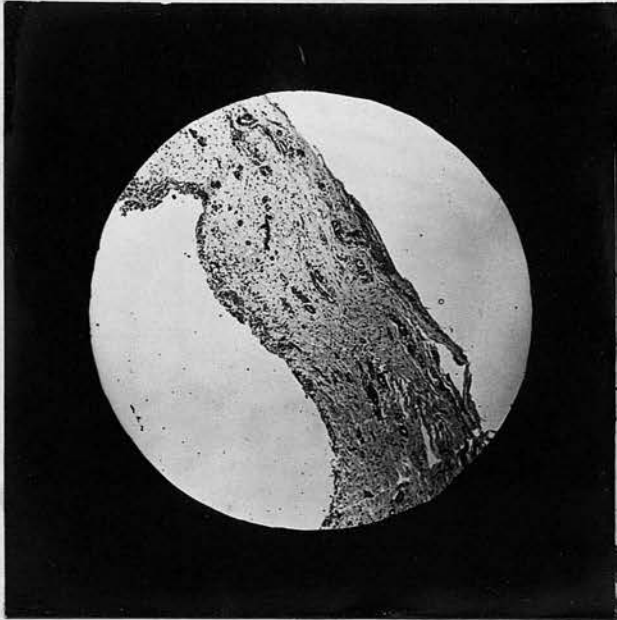
MICROSCOPIC EXAMINATION OF THE HERNIAL SACS AND

THE DEDUCTIONS DRAWN THEREFROM.

If one removes and examines a hernia sac one finds its character something as follows:-

It is a comparatively thin saccular process, its outer surface is roughened, and adherent to it in parts one finds traces of the infundibuliform and cremasteric fascias, and perhaps some fibres of the cremasteric muscle. The inner surface is smooth and glistening with all the character of a serous membrane.

When/



A. Fraser

Low power view of a hernial sac.

When examined microscopically its walls are found to be composed of several layers. First, internal, one saws a layer (usually single) of flattened lining epithelium, large flat cells with deeply staining nuclei - in places approaching a cubical type. These rested upon a thin basement membrane, beyond which came a layer of fibrous tissue, intermingled with a varying proportion of round cells. Through this layer there coursed numerous blood vessels, which are discussed more particularly later. Lying quite outside the sac wall one noticed strands of muscular fibres derived from the cremasteric muscle.

In the course of our investigation we have undertaken the microscopic examination of a number of hernial sacs, and we venture to differ from Mr Carmichael, who in an article in the British Medical Journal, Aug. 29, 1908, says:- "That the histological appearances of the sac in most cases do not afford reliable evidence of its congenital origin or otherwise." Carmichael's investigations were conducted along the lines of a comparison of the structures of the tunica vaginalis and the parietal peritoneum; and, arguing from the thickness of the sac wall, he associated the thick sac with the tunica/

tunica vaginalis testis, the thin sac with the parietal peritoneum. The former, he suggested, corresponded to the congenital sac, the latter to the acquired type.

These deductions, while certainly ingenious, are rather apt to be upset when one considers the variety of external agencies which go to form a thickened sac - trusses, chronic inflammatory changes, etc.

Upon examining these sacs, we have noted a variety of histological structures which have been arranged and classified as follows:-

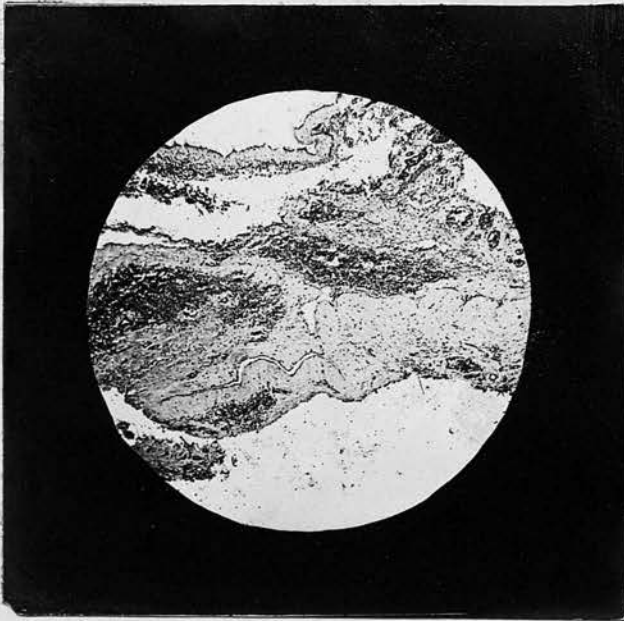
Class A. The importance of the relative amount of fibrous tissue present in the sac wall; it varied greatly in amount and in the degree of its density.

Class B. The importance of the relative amount of cellular element present, existing as large round cells lying between the strands of the fibrous tissue. This class also shewed great variation.

Class C. The degree of vascularity present.

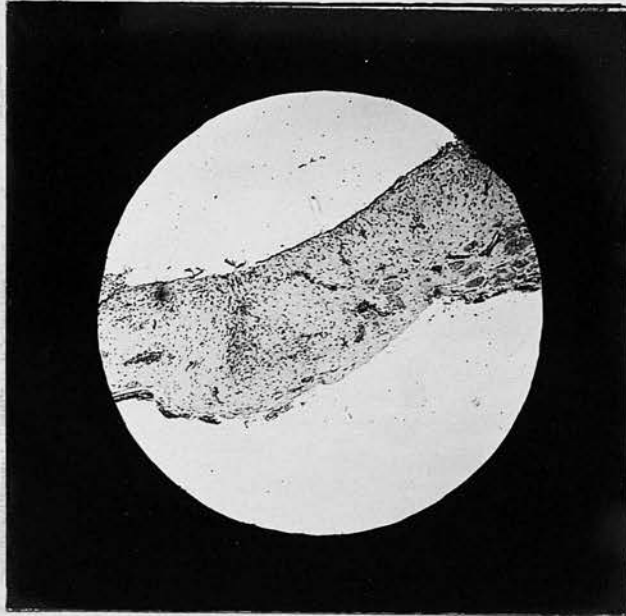
Class D. The histological characters of the blood vessel walls; the variation extended from the blood lacunae with no definite wall to the fully formed and developed blood vessel wall.

Passing to a more detailed discussion of these remarks, the first point to arrest our attention was the fact that/



H7R200R

Section of the fibrous type of sac; the lumen of the sac is seen - note the scanty number of cells in the sac wall.



A. Feazen

Section of the Cellular or Embryonic type of sac.

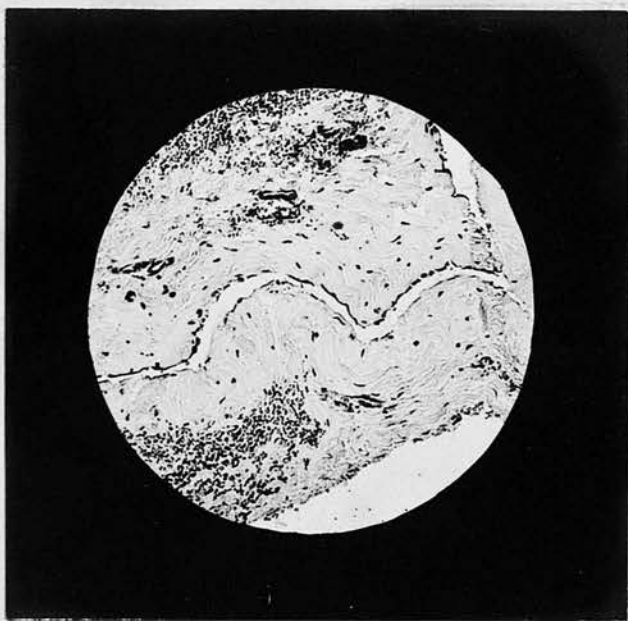
Note the large number of cells present in the sac wall;

Compare with the former section.

that a number of the slides shewed a marked fibrous condition of the sac wall, here and there a few round cells could be seen, some elongated and approaching near the characters of fibroblasts. Other sections shewed quite a different structure, the cellular element had increased enormously, the cells present were similar in character to those of the previous class, but fibro-blastic cells were scarce.

These observations can, to our mind,, bear but one representation, they indicate the progression from an embryonic to a more fully developed tissue. The respective degree of the round cells or fibrous tissue element present, the formation of fibrous tissue by fibro blasts; these points all indicate a progressive development of the sac wall.

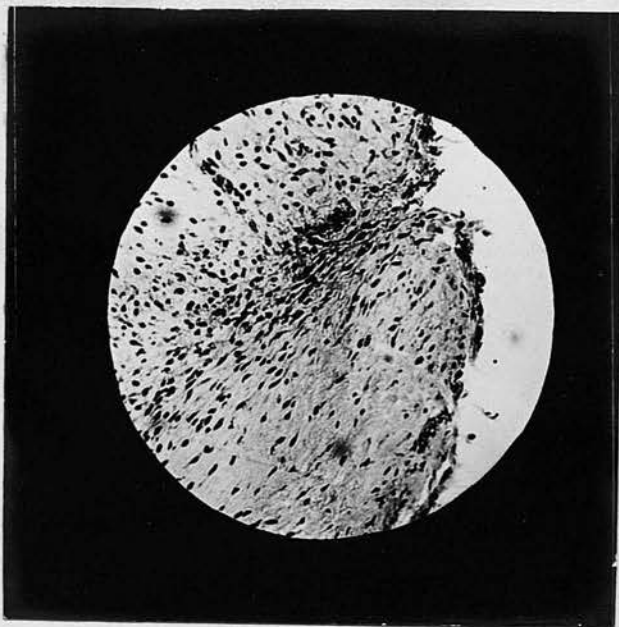
Our next investigation was directed to find out whether any particular attention could be directed to those changes. Could they bear a relationship to the age of the patient? For if one could shew that the embryonic type of sac, as we shall call it, corresponded in every case to the hernia of a child a few months old, while the fibrous condition increased with age, such a demonstration would afford very strong proof of the congenital origin of all inguinal hernias. Or, according to Russel, "all" - oblique inguinal hernias/"



A PRIMER

High power photograph of the fibrous type of sac.

Note the absence of cells, also the endothelium lining the lumen.



A. PRATER

High power photograph of the Embryonic type of sac.
Note the number of round cells - many becoming
fibroblastic in type.

hernias which are met with during adolescence and in young adults are essentially congenital." R.H.Russel,
Lancet, May 12, 1904.

Internat. Med. Jour. of Australia, Jan. 24th, 1904.

But when we came to tabulate our results, we found such a position untenable. The following table has been formed from the investigations upon a selected number of hernial sacs illustrating all ages:-

Age.	Microscopic Character of Sac Wall.
<u>3 months</u>	<u>Marked cellular element present, (embryonic).</u>
<u>6 months</u>	<u>Cellular element at a minimum, fibrosis well marked.</u>
<u>8 months</u>	<u>Dense fibrous tissue, practically no round cells.</u>
<u>9 months</u>	<u>Fairly distinct round cell element, considerable vascularity.</u>
<u>2 years</u>	<u>Dense fibrous tissue, no round cells.</u>
<u>3 years</u>	<u>Enormous round celled infiltration, (embryonic).</u>
<u>4 years</u>	<u>Well marked fibrous tissue, few round cells.</u>
<u>6 years</u>	<u>Dense fibrous tissue, few round cells.</u>
<u>8 years</u>	<u>Dense fibrous tissue, very few round cells.</u>
<u>10 years</u>	<u>Well marked cellular infiltration.</u>

A glance at such a table shews us that the question of age bears no relation to the hernia. So that we are driven back upon the fact that now and then we/

we find isolated examples of hernia sacs which bear histological characters closely resembling those of embryonic tissue. These are, therefore, in our opinion, examples of true congenital sacs.

The degree of vascularity present and the microscopical characters of the vessel walls will be considered together. We know that prominent characteristics of the embryonic tissue are its comparative vascularity and the primitive development of its vessel walls.

The embryonic types of hernia sacs illustrate beautifully both of these peculiarities. The vessels are numerous, but are merely channels coursing between the cells lined with, often, only a single layer of flattened cells, yet packed full of blood corpuscles. The more fibrous type demonstrates a lesser degree of vascularity, yet the walls of its vessels are completely developed with its several coats.

These facts add yet another proof that certain oblique inguinal sacs possess histological characteristics which strongly suggest a pure congenital origin. We would summarise our observations as follows:-

A. That a certain proportion of hernial sacs possess histological features which bear a resemblance to embryonic tissue:-

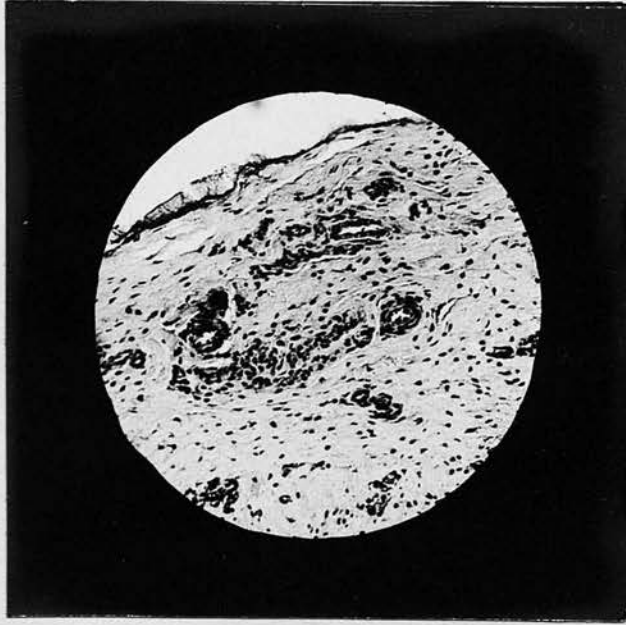
1. On account of the round cell element present.

2./



A. FRAZER

Section of Blood Vessels in embryonic sac. Note the imperfect development of the vessel wall.



H. FRAZER

Section of Blood Vessels in Fibrous type of sac.

The vessels shew complete development.

2. On account of the primitive condition of the vessel walls.
- B. That a certain proportion of hernia sacs possess the histological character of full developed fibrous tissue, etc.
- C. That those sacs which demonstrate what one might call an "Embryonic" structure are essentially congenital in origin.

These conclusions are further supported by embryological investigation.

At an early period of development the embryo is arranged in its thin primary layers and, at a later period, becomes a more highly organised body, containing the rudiments of an alimentary canal and a pleuro peritoneal cavity. — The splanchnopleure closing in the primitive alimentary canal and the somatopleure constituting the body wall. — Between these two layers the pleuro peritoneal cavity lies, lined throughout with mesoderm tissue upon the inner layer, ^{of} which flattened and stratified cells become specialised as the endothileal structure of the peritoneum. In the process of development the somatopleure undergoes pouching. It may be in the femoral region or it may be in the inguinal, to form what we afterwards know as the processus vaginalis, which, though related to the descent/

descent of the testis is none the less a pouching.

Should such a formation occur in the process of development we should expect it to shew a structure different in character to that found in a pouch formed after birth. The true congenital pouch has been formed directly from the mesoblastic while it still retained its embryological characteristics. It is, therefore, much more likely to demonstrate a pseudo-embryonic structure than the pouch which has been formed more or less mechanically from the peritoneum, when the latter has acquired its fully organised properties.

Now we have shewn that certain hernial sacs possess the cellular and vascular characteristics which one associates with embryonic tissues, while other sacs are fibrous in character and possess the fully developed vessels of later tissues.

These further observations would suggest that the above mentioned facts have an important bearing upon the origin of inguinal hernia.

The suggestion is, that those sacs which present the cellular and vascular characters akin to embryological tissue have been embryonic in their origin, in other words, congenital; while the sac whose walls are composed of fully formed fibrous tissue with the normal/

normal type of vessel has been formed when the tissues had reached their full development, in other words, they have been acquired.

Of course one must bear in mind the possibility that the embryonic and fibrous sacs may be but stages in the development of the sac, quite irrespective of age, and with a view to elucidating this possibility we have examined a further number of sacs at all ages. The facts which we considered important are classified in the following tables:-

Age.	Condition of sac.
1. 7 yrs.	Specimen from an encysted hydrocele, will shew an example of original peritoneum, fairly strongly cellular.
2. 3 yrs.	Strongly cellular, but blood vessels shew some thickening.
3. Age unknown.	Pure fibrous sac.
4. 7 yrs.	Strongly fibrous, thickened blood vessels, good example of epithelium.
5. $1\frac{1}{2}$ yrs.	Transition stage, cellular element is fairly plentiful.
* 6. 5 months.	Organisation of sac, shews nothing else.
* 7. 3 months.	Fibrous sac, thickened blood vessels.
8. 5 months.	Cellular sac, thin walled blood vessels.
9. 6 months.	Fibrous, shews good example of thickened blood vessels.
10. $1\frac{8}{12}$ yrs.	Cellular sac, blood vessels are imperfect.
11./	

	Age.	Condition.
11.	16 months.	Cellular sac, medium blood vessels, good endothelium.
12.	A. V.	Transition state, fibro cellular, blood vessels thickened.
13.	A. V.	Very cellular, most marked one seen.
14.	A. V.	Fibrous sac, shows the progression beautifully of fibro blastic into fibrous tissue.
15.	A. V.	Fibrous sac, small degree of cellular tissue, blood vessels?
16.	3 yrs.	Fibro cellular, transition state.
17.	6 yrs.	Cellular element increased, epididymis reflection.
18.	10 months.	Pure fibrous sac, imperfect blood vessels.
19.	10 months.	Pure fibrous sac, fully developed blood vessels.
20.	5 months.	Pure fibrous sac, imperfect blood vessels.
21.	6 months.	Pure fibrous sac, imperfect blood vessels.
22.	7 months.	Fibrous, slight cellular element, well formed blood vessels.
23.	Age unknown.	Pure fibrous tissue, no cellular element whatsoever, some myxomatous change.
24.	Age unknown.	Fibrous sac, well developed blood vessels, slight cellular element.
24.	Age unknown.	Plentiful cellular element, imperfect blood vessels.
26.	Vass. 28:12:07.	Fibrous sac, thickened blood vessels.
27.	5 ⁹ /12 yrs.	<u>Complete section of testicle, shews testes covered by fibro cellular tissue and covered by distinct cubical epithelium.</u>
28//		

Age.	Condition.
28. 4 months.	Obliterated sac, shews dense fibrous tissue, well developed blood vessels.
29. 5 months.	E.S. Well marked cellular sac, poorly developed blood vessels.
30. 13 months.	Strongly cellular, well developed blood vessels.
31. 3 years.	Fibrous sac, good blood vessels, compare with <u>No. 12.</u>
32. 13 months.	Fibro cellular, plentiful cellular element, medium blood vessels.
33. 14 months.	Strong fibrous tissue, thickened blood vessels.
34. 8 months.	Fibrous sac, no cellular tissue, thickened blood vessels.
35. 4 years.	Strongly cellular, imperfect blood vessels.
36. A. V.	Fibro cellular, blood vessels shew some thickening.
37. A. V.	Fibro cellular, fibres at deeper parts, blood vessels?
38. A. V.	Cellular sac, thin walled vessels.
39. 3 months.	Marked cellular sac, embryonic blood vessels.
40. 6 months.	Fibrous sac, cellular element almost absent.
41. 8 months.	Dense fibrous sac, no cellular element.
42. 9 months.	Round celled element, vascular.
43. 2 years.	Dense fibrous sac, diminished vascularity.
44. 3 years.	Cellular sac, embryonic.
45. 4 years.	Well marked fibrous sac.
46. 6 years.	well marked fibrous sac, no blood vessels.
47. 8 years.	Fibrous sac, few cells.
48. 10 years.	Cellular sac, embryonic.

In an examination of these cases one had no difficulty in distinguishing the ^{fibrous} ~~embryonic~~ and the cellular types. But one was left with a type possessing characters resembling in some ways the embryonic and in other particulars the fibrous sac. We have called this type the transition sac. It possesses a certain cellular element and yet not sufficient to justify its classification as an embryonic sac. Its blood vessels are fairly numerous and the walls shew a stage of development in advance of that of the embryonic type.

How is one to deal with this problem? The most likely explanation is offered by the theory of a development from the embryonic to the true fibrous sac, the transition sac illustrating a mid point in the development. As we have shewn, the histological characters of a processus vaginalis consist of a loose fibro cellular tissue, lined by a flattened endothelium. The cellular tissue is well marked and the existing blood vessels are mere thin walled channels. It is necessary to draw attention to the fact of how closely this description corresponds to that of the embryonic sac. The transition sac still shews a distinct resemblance to the processus vaginalis, but there is an advance in its development. The fibrous element is increased/

increased at the expense of the cellular element.

The blood vessels possess a definite wall.

Lastly, there comes the fibrous sac. The cellular element has largely disappeared. The fibrous tissue is dense and well formed. The blood vessels shew an actual thickening, which the accompanying microphotograph well illustrates.

As we said, it would appear that these three stages are progressive in the development of the sac. The thickening of the blood vessels is a point of some interest, and it suggests the possibility that it is this vascular thickening in the medium which produced the fibrosis of the sac.

To summarise: we have, from a microscopic examination of a large number of hernia sacs, deduced one fact and two suppositions.

The fact is that hernia sacs possess definite histological characteristics which enable one to classify them into three distinct divisions:-

1. Embryonic.
2. Transitional.
3. Fibrous.

The suppositions are:-

- A. That the histological characters mentioned above indicate/

indicate that embryonic sacs are truly congenital in origin, the fibrous being acquired, the transitional type being classed with one or other, according as the fibrous or cellular element predominates.

Supposition B.

That the three types of sac indicate a progressive development in the history of the sac, the original or true congenital sac corresponding to the embryonic type, which embryonic type undergoes a gradual development or degeneration through the transitional type to the fully formed fibrous sac.

S U M M A R Y .

The original nucleus of this thesis was embodied in a study of 1000 cases of oblique inguinal hernia, occurring in children under 12 years old, the case records being obtainable through the kindness of Mr Stiles.

To complete the Study of the subject, it was necessary to discuss the question of testicular descent in relation to the formation of the Processus Vaginalis. Under the heading, Descent of the Testes, we have introduced some points which we can claim as original:-

- A. The fact that the testes do not actually descend until after the 5th month.
- B. The interrogation of this fact by observing that the descent of the testes occurs only after the Gubernaculum has formed a definite attachment to Symphysis Pubis.
- C. The part which the abdominal muscles play in forcing the testis along the Inguinal Canal.
- D. The importance of the different varieties of structure in the Gubernaculum, more especially in the presence or absence of muscular fibres.
- E. The early formation of the Processus Vaginalis being an active phenomenon depending upon a ^{Special} Spinal structure in its wall.
- F. The later formation of the processus being dependent upon the descent of the Gubernaculum.

We/

We have briefly outlined some of the more important clinical aspects of Inguinal hernia. And finally, we have drawn attention to the possibility of clearing up the question of hernial origin (congenital or acquired) by a microscopic examination of the hernial sac.
